
Depleted Uranium Hexafluoride Management Program: Data Compilation for the Paducah Site

**in Support of Site-Specific NEPA Requirements
for Continued Cylinder Storage, Cylinder Preparation,
Conversion, and Long-Term Storage Activities**

**Environmental Assessment Division
Argonne National Laboratory**

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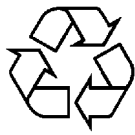
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Compiled by H.M. Hartmann

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CONTENTS

ACKNOWLEDGMENTS	xxiii
NOTATION	xxv
ABSTRACT	1-1
1 INTRODUCTION AND BACKGROUND	1-1
2 AFFECTED ENVIRONMENT	2-1
2.1 Cylinder Yards	2-3
2.2 Site Infrastructure	2-5
2.3 Ambient Air Quality and Airborne Emissions	2-5
2.4 Geology and Soil	2-7
2.4.1 Topography, Structure, and Seismic Risk	2-7
2.4.2 Soil	2-8
2.5 Water Resources	2-9
2.5.1 Surface Water	2-9
2.5.2 Groundwater	2-10
2.6 Biotic Resources	2-11
2.6.1 Vegetation	2-11
2.6.2 Wildlife	2-11
2.6.3 Wetlands	2-13
2.6.4 Threatened and Endangered Species	2-13
2.7 Public and Occupational Health and Safety	2-13
2.7.1 Radiation Environment	2-13
2.7.2 Chemical Environment	2-14
2.8 Socioeconomics	2-14
2.8.1 Regional Economic Activity	2-17
2.8.2 Population	2-17
2.8.3 Housing	2-17
2.8.4 Public Finance	2-17
2.9 Waste Management	2-18
2.9.1 Wastewater	2-19
2.9.2 Solid Nonhazardous, Nonradioactive Waste	2-20
2.9.3 Nonradioactive Hazardous and Toxic Waste	2-20
2.9.4 Low-Level Waste	2-21
2.9.5 Low-Level Mixed Waste	2-21
2.10 Cultural Resources	2-21
2.11 Minority and Low-Income Populations	2-22
3 ENVIRONMENTAL IMPACTS OF CONTINUED CYLINDER STORAGE AT THE PADUCAH SITE	3-1
3.1 Summary of Continued Cylinder Storage Impacts	3-5

CONTENTS (Cont.)

3.2	Potential Impacts of Continued Cylinder Storage for the No Action Alternative	3-14
3.2.1	Human Health — Normal Operations	3-15
3.2.1.1	Radiological Impacts	3-15
3.2.1.2	Chemical Impacts	3-19
3.2.2	Human Health — Accident Conditions	3-19
3.2.2.1	Radiological Impacts	3-21
3.2.2.2	Chemical Impacts	3-25
3.2.2.3	Physical Hazards	3-28
3.2.3	Air Quality	3-29
3.2.4	Water and Soil	3-31
3.2.4.1	Surface Water	3-31
3.2.4.2	Groundwater	3-33
3.2.4.3	Soil	3-33
3.2.5	Socioeconomics	3-34
3.2.6	Ecology	3-36
3.2.7	Waste Management	3-38
3.2.8	Resource Requirements	3-39
3.2.9	Land Use	3-41
3.2.10	Cultural Resources	3-41
3.2.11	Environmental Justice	3-41
3.2.12	Other Impacts Considered But Not Analyzed in Detail	3-42
3.3	Potential Impacts of Continued Cylinder Storage Based on Uncertainties in Corrosion Control	3-42
3.4	Potential Impacts of Continued Cylinder Storage for the Action Alternatives	3-43
3.4.1	Human Health — Normal Operations	3-44
3.4.1.1	Radiological Impacts	3-44
3.4.1.2	Chemical Impacts	3-47
3.4.2	Human Health — Accident Conditions	3-47
3.4.3	Air Quality	3-49
3.4.4	Water and Soil	3-49
3.4.4.1	Surface Water	3-49
3.4.4.2	Groundwater	3-50
3.4.4.3	Soil	3-52
3.4.5	Socioeconomics	3-52
3.4.6	Ecology	3-52
3.4.7	Waste Management	3-54
3.4.8	Resource Requirements	3-54
3.4.9	Land Use	3-56
3.4.10	Cultural Resources	3-56
3.4.11	Environmental Justice	3-56
3.5	Potential Environmental Impacts Associated with Continued Storage of the Entire Paducah Site Cylinder Inventory	3-57

CONTENTS (Cont.)

3.5.1	Approach Used to Evaluate the Environmental Impacts of Continued Storage of the USEC Cylinders	3-57
3.5.2	Potential Environmental Impacts from Continued Storage of the Entire Cylinder Inventory under the No Action Alternative	3-58
3.5.2.1	Human Health and Safety — Normal Operations	3-58
3.5.2.2	Human Health and Safety — Accident Conditions	3-59
3.5.2.3	Transportation	3-60
3.5.2.4	Air Quality	3-60
3.5.2.5	Water and Soil	3-61
3.5.2.6	Socioeconomics	3-61
3.5.2.7	Ecology	3-62
3.5.2.8	Waste Management	3-62
3.5.2.9	Resource Requirements	3-62
3.5.2.10	Land Use	3-63
3.5.2.11	Cultural Resources	3-63
3.5.2.12	Environmental Justice	3-63
3.5.3	Potential Environmental Impacts from Continued Storage of the Entire Cylinder Inventory under the Action Alternatives	3-63
3.5.3.1	Human Health and Safety — Normal Operations	3-63
3.5.3.2	Human Health and Safety — Accident Conditions	3-65
3.5.3.3	Transportation	3-65
3.5.3.4	Air Quality	3-65
3.5.3.5	Water and Soil	3-66
3.5.3.6	Socioeconomics	3-66
3.5.3.7	Ecology	3-67
3.5.3.8	Waste Management	3-67
3.5.3.9	Resource Requirements	3-67
3.5.3.10	Land Use	3-68
3.5.3.11	Cultural Resources	3-68
3.5.3.12	Environmental Justice	3-68
4	ENVIRONMENTAL IMPACTS OF OPTIONS FOR PREPARING CYLINDERS FOR SHIPMENT OR LONG-TERM STORAGE AT THE PADUCAH SITE	4-1
4.1	Summary of Cylinder Preparation Option Impacts	4-2
4.2	Description of Options	4-3
4.2.1	Cylinder Overcontainers	4-8
4.2.2	Cylinder Transfer	4-8
4.3	Impacts of Options	4-9
4.3.1	Human Health — Normal Operations	4-11
4.3.1.1	Radiological Impacts	4-11
4.3.1.2	Chemical Impacts	4-16
4.3.2	Human Health — Accident Conditions	4-17
4.3.2.1	Radiological Impacts	4-17
4.3.2.2	Chemical Impacts	4-22

CONTENTS (Cont.)

4.3.2.3	Physical Hazards	4-25
4.3.3	Air Quality	4-26
4.3.4	Water and Soil	4-30
4.3.4.1	Surface Water	4-30
4.3.4.2	Groundwater	4-31
4.3.4.3	Soil	4-32
4.3.5	Socioeconomics	4-33
4.3.5.1	Impacts from Cylinder Preparation Using Overcontainers	4-35
4.3.5.2	Impacts from a Cylinder Transfer Facility	4-35
4.3.5.3	Impacts from Standard Cylinder Preparation	4-36
4.3.6	Ecology	4-37
4.3.7	Waste Management	4-40
4.3.8	Resource Requirements	4-42
4.3.9	Land Use	4-43
4.3.10	Cultural Resources	4-45
4.3.11	Environmental Justice	4-45
4.3.12	Other Impacts Considered But Not Analyzed in Detail	4-45
4.4	Potential Environmental Impacts Associated with Preparing the Entire Paducah Site Cylinder Inventory for Shipment or Storage	4-46
4.4.1	Approach Used to Evaluate the Environmental Impacts of Cylinder Preparation for the USEC Cylinders	4-46
4.4.2	Potential Environmental Impacts from Preparation of the Entire Paducah Site Cylinder Inventory for Shipment or Long-Term Storage	4-46
4.4.2.1	Human Health and Safety — Normal Operations	4-46
4.4.2.2	Human Health and Safety — Accident Conditions	4-47
4.4.2.3	Transportation	4-48
4.4.2.4	Air Quality	4-48
4.4.2.5	Water and Soil	4-48
4.4.2.6	Socioeconomics	4-49
4.4.2.7	Ecology	4-49
4.4.2.8	Waste Management	4-49
4.4.2.9	Resource Requirements	4-49
4.4.2.10	Land Use	4-50
4.4.2.11	Cultural Resources	4-50
4.4.2.12	Environmental Justice	4-50
5	ENVIRONMENTAL IMPACTS OF OPTIONS FOR CONVERSION OF UF ₆ TO OXIDE OR METAL AT THE PADUCAH SITE	5-1
5.1	Summary of Conversion Option Impacts	5-4
5.2	Description of Options	5-4
5.2.1	Conversion to U ₃ O ₈	5-11
5.2.2	Conversion to UO ₂	5-12
5.2.3	Conversion to Metal	5-13

CONTENTS (Cont.)

5.2.4	Conversion Technologies and Chemical Forms Considered But Not Analyzed in Detail	5-14
5.3	Impacts of Options	5-14
5.3.1	Human Health — Normal Operations	5-15
5.3.1.1	Radiological Impacts	5-15
5.3.1.2	Chemical Impacts	5-22
5.3.2	Human Health — Accident Conditions	5-22
5.3.2.1	Radiological Impacts	5-31
5.3.2.2	Chemical Impacts	5-31
5.3.2.3	Physical Hazards	5-37
5.3.3	Air Quality	5-38
5.3.3.1	Construction	5-39
5.3.3.2	Operations	5-41
5.3.4	Water and Soil	5-46
5.3.4.1	Surface Water	5-46
5.3.4.2	Groundwater	5-49
5.3.4.3	Soil	5-52
5.3.5	Socioeconomics	5-53
5.3.5.1	Conversion to U_3O_8	5-54
5.3.5.2	Conversion to UO_2	5-56
5.3.5.3	Conversion to Metal	5-57
5.3.5.4	Cylinder Treatment Facility	5-57
5.3.6	Ecology	5-58
5.3.6.1	Conversion to U_3O_8	5-58
5.3.6.2	Conversion to UO_2	5-61
5.3.6.3	Conversion to Metal	5-62
5.3.7	Waste Management	5-63
5.3.7.1	Conversion to U_3O_8	5-63
5.3.7.2	Conversion to UO_2	5-65
5.3.7.3	Conversion to Metal	5-66
5.3.7.4	Cylinder Treatment Facility	5-67
5.3.7.5	Summary	5-68
5.3.8	Resource Requirements	5-69
5.3.9	Land Use	5-70
5.3.9.1	Conversion to U_3O_8	5-70
5.3.9.2	Conversion to UO_2	5-70
5.3.9.3	Conversion to Metal	5-72
5.3.9.4	Cylinder Treatment Facility	5-72
5.3.10	Other Impacts Considered But Not Analyzed in Detail	5-73
5.4	Potential Environmental Impacts Associated with Conversion of the Entire Cylinder Inventory at the Paducah Site	5-73
5.4.1	Approach Used to Evaluate the Environmental Impacts of Conversion for the Entire Cylinder Inventory	5-74
5.4.2	Potential Environmental Impacts from Conversion of the Entire Cylinder Inventory	5-74

CONTENTS (Cont.)

5.4.2.1	Human Health and Safety — Normal Operations	5-74
5.4.2.2	Human Health and Safety — Accident Conditions	5-75
5.4.2.3	Air Quality	5-75
5.4.2.4	Water and Soil	5-75
5.4.2.5	Socioeconomics	5-76
5.4.2.6	Ecology	5-76
5.4.2.7	Waste Management	5-76
5.4.2.8	Resource Requirements	5-78
5.4.2.9	Land Use	5-78
5.4.2.10	Cultural Resources	5-78
5.4.2.11	Environmental Justice	5-78
6	ENVIRONMENTAL IMPACTS OF OPTIONS FOR LONG-TERM STORAGE AS UF ₆ AND URANIUM OXIDE AT THE PADUCAH SITE	6-1
6.1	Summary of Storage Option Impacts	6-3
6.2	Description of Options	6-13
6.2.1	Storage in Yards	6-14
6.2.2	Storage in Buildings	6-15
6.2.3	Storage in Vaults	6-15
6.2.4	Storage Technologies and Chemical Forms Considered But Not Analyzed	6-15
6.3	Impacts of Options	6-15
6.3.1	Human Health — Normal Operations	6-16
6.3.1.1	Radiological Impacts	6-16
6.3.1.2	Chemical Impacts	6-20
6.3.2	Human Health — Accident Conditions	6-22
6.3.2.1	Radiological Impacts	6-25
6.3.2.2	Chemical Impacts	6-25
6.3.2.3	Physical Hazards	6-31
6.3.3	Air Quality	6-32
6.3.4	Water and Soil	6-35
6.3.4.1	Surface Water	6-35
6.3.4.2	Groundwater	6-39
6.3.4.3	Soil	6-40
6.3.5	Socioeconomics	6-41
6.3.5.1	Long-Term Storage as UF ₆	6-42
6.3.5.2	Long-Term Storage as UO ₂	6-44
6.3.5.3	Long-Term Storage as U ₃ O ₈	6-45
6.3.6	Ecology	6-45
6.3.6.1	Storage as UF ₆	6-46
6.3.6.2	Storage as U ₃ O ₈	6-48
6.3.6.3	Storage as UO ₂	6-49
6.3.7	Waste Management	6-50
6.3.7.1	Storage of UF ₆ in Yards and Buildings	6-50

CONTENTS (Cont.)

6.3.7.2	Storage of U_3O_8 and UO_2 in Buildings and Vaults	6-52
6.3.7.3	Summary	6-54
6.3.8	Resource Requirements	6-54
6.3.9	Land Use	6-56
6.3.9.1	Storage as UF_6	6-57
6.3.9.2	Storage as U_3O_8	6-58
6.3.9.3	Storage as UO_2	6-58
6.3.10	Other Impacts Considered But Not Analyzed in Detail	6-58
6.4	Potential Environmental Impacts Associated with Long-Term Storage of the Entire Cylinder Inventory at the Paducah Site	6-59
6.4.1	Approach Used to Evaluate the Environmental Impacts of Long-Term Storage for the Entire Cylinder Inventory	6-59
6.4.2	Potential Environmental Impacts from Long-Term Storage of the Entire Cylinder Inventory	6-60
6.4.2.1	Human Health and Safety — Normal Operations	6-60
6.4.2.2	Human Health and Safety — Accident Conditions	6-60
6.4.2.3	Air Quality	6-61
6.4.2.4	Water and Soil	6-61
6.4.2.5	Socioeconomics	6-62
6.4.2.6	Ecology	6-62
6.4.2.7	Waste Management	6-62
6.4.2.8	Resource Requirements	6-63
6.4.2.9	Land Use	6-63
6.4.2.10	Cultural Resources	6-63
6.4.2.11	Environmental Justice	6-63
7	CUMULATIVE IMPACTS	7-1
7.1	Cumulative Impact Issues and Assumptions	7-1
7.2	Impacts of Continued Cylinder Storage and Preparation	7-4
8	PARAMETRIC ANALYSIS: ENVIRONMENTAL IMPACTS OF CONVERSION AND LONG-TERM STORAGE OPTIONS FOR PROCESSING LESS THAN THE TOTAL DEPLETED UF_6 INVENTORY AT THE PADUCAH SITE	8-1
8.1	Parametric Analysis Assessment Approach	8-2
8.2	Conversion Options	8-3
8.2.1	Human Health — Normal Operations	8-4
8.2.1.1	Radiological Impacts	8-4
8.2.1.2	Chemical Impacts	8-18
8.2.2	Human Health — Accident Conditions	8-18
8.2.2.1	Radiological Impacts	8-18
8.2.2.2	Chemical Impacts	8-19
8.2.2.3	Physical Hazards	8-19
8.2.3	Air Quality	8-20

CONTENTS (Cont.)

8.2.4	Water and Soil	8-23
8.2.4.1	Surface Water	8-23
8.2.4.2	Groundwater	8-23
8.2.4.3	Soil	8-23
8.2.5	Socioeconomics	8-24
8.2.6	Ecology	8-24
8.2.7	Waste Management	8-25
8.2.8	Resource Requirements	8-25
8.2.9	Land Use	8-27
8.2.9.1	Conversion to U_3O_8	8-27
8.2.9.2	Conversion to UO_2	8-27
8.2.9.3	Conversion to Uranium Metal	8-28
8.2.9.4	Cylinder Treatment Facility	8-28
8.2.10	Other Impacts Considered But Not Analyzed in Detail	8-29
8.3	Long-Term Storage Options	8-29
8.3.1	Human Health — Normal Operations	8-30
8.3.1.1	Radiological Impacts	8-30
8.3.1.2	Chemical Impacts	8-30
8.3.2	Human Health — Accident Conditions	8-34
8.3.2.1	Radiological Impacts	8-34
8.3.2.2	Chemical Impacts	8-34
8.3.2.3	Physical Hazards	8-35
8.3.3	Air Quality	8-37
8.3.4	Water and Soil	8-37
8.3.4.1	Surface Water	8-37
8.3.4.2	Groundwater	8-37
8.3.4.3	Soil	8-38
8.3.5	Socioeconomics	8-38
8.3.6	Ecology	8-38
8.3.7	Waste Management	8-39
8.3.8	Resource Requirements	8-39
8.3.9	Land Use	8-40
8.3.10	Other Impacts Considered But Not Analyzed in Detail	8-41
9	REFERENCES	9-1

TABLES

2.1	Locations of Cylinders of DOE-Generated Depleted UF_6 at the Paducah Site	2-3
2.2	Kentucky Ambient Air Quality Standards	2-6

TABLES (Cont.)

2.3	Estimated Radiation Doses to Members of the General Public and to Cylinder Yard Workers at the Paducah Gaseous Diffusion Plant	2-15
2.4	Estimated Hazard Quotients for Members of the General Public near the Paducah Site under Existing Environmental Conditions	2-16
2.5	Summary of Financial Characteristics for the Paducah Site County, City, and School District Regions of Influence	2-18
2.6	Projected Site and National DOE Waste Treatment Volumes	2-19
3.1	Estimated Number of Breaches and Releases from 28,351 DOE-Generated Cylinders at the Paducah Site from 1999 through 2039, Assuming Control of External Corrosion by Painting	3-4
3.2	Estimated Number of Breaches and Releases from DOE-Generated Cylinders at the Paducah Site from 1999 through 2039, Assuming Historical Corrosion Rates	3-6
3.3	Summary of Continued Cylinder Storage Impacts at the Paducah Site	3-8
3.4	Radiological Doses from Continued Cylinder Storage at the Paducah Site under Normal Operations for the No Action Alternative	3-17
3.5	Latent Cancer Risks from Continued Cylinder Storage at the Paducah Site under Normal Operations for the No Action Alternative	3-18
3.6	Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-19
3.7	Chemical Impacts to Human Health from Continued Cylinder Storage at the Paducah Site under Normal Operations for the No Action Alternative	3-20
3.8	Accidents Considered for the Continued Storage Option at the Paducah Site	3-22
3.9	Estimated Radiological Doses per Accident Occurrence for Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-23
3.10	Estimated Radiological Health Risks per Accident Occurrence for Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-24
3.11	Number of Persons with Potential for Adverse Effects from Accidents under Continued Cylinder Storage at the Paducah Site for the No Action Alternative	3-26

TABLES (Cont.)

3.12	Number of Persons with Potential for Irreversible Adverse Effects from Accidents under Continued Cylinder Storage at the Paducah Site for the No Action Alternative	3-27
3.13	Maximum Concentrations of Criteria Pollutants at Paducah Site Boundaries during Yard Construction	3-30
3.14	Maximum Concentrations of Criteria Pollutants at Paducah Site Boundaries due to Cylinder Relocations	3-30
3.15	Maximum Concentrations of Criteria Pollutants at Paducah Site Boundaries due to Cylinder Painting	3-32
3.16	Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the Paducah Site under the No Action Alternative	3-32
3.17	Maximum Uranium Concentrations in Surface Waters for Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-33
3.18	Groundwater Concentrations for Continued Cylinder Storage at the Paducah Site for Two Soil Characteristics under the No Action Alternative	3-34
3.19	Potential Socioeconomic Impacts of Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-36
3.20	Potential Impacts to Ecological Resources from Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-37
3.21	Total Waste Generated during Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-38
3.22	Resource Requirements for Construction and Operations for Continued Cylinder Storage at the Paducah Site under the No Action Alternative	3-40
3.23	Radiological Doses from Continued Cylinder Storage under Normal Operations at the Paducah Site for the Action Alternatives	3-45
3.24	Latent Cancer Risks from Continued Cylinder Storage under Normal Operations at the Paducah Site for the Action Alternatives	3-46
3.25	Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage at the Paducah Site under the Action Alternatives	3-47

TABLES (Cont.)

3.26	Chemical Impacts to Human Health from Continued Cylinder Storage under Normal Operations at the Paducah Site for the Action Alternatives	3-48
3.27	Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the Paducah Site for the Action Alternatives	3-50
3.28	Maximum Uranium Concentrations in Surface Waters for Continued Cylinder Storage at the Paducah Site under the Action Alternatives	3-51
3.29	Groundwater Concentrations for Continued Cylinder Storage for Two Soil Characteristics at the Paducah Site under the Action Alternatives	3-51
3.30	Potential Socioeconomic Impacts of Continued Cylinder Storage at the Paducah Site under the Action Alternatives	3-53
3.31	Total Waste Generated at the Paducah Site during Continued Cylinder Storage under the Action Alternatives	3-54
3.32	Resource Requirements for Construction and Operations for Continued Cylinder Storage at the Paducah Site under the Action Alternatives	3-55
4.1	Summary of Cylinder Preparation Impacts for the Paducah Site	4-4
4.2	Accidents Considered for the Cylinder Preparation Options	4-18
4.3	Estimated Radiological Doses per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site	4-20
4.4	Estimated Radiological Health Risks per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site	4-21
4.5	Number of Persons with Potential for Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site	4-23
4.6	Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site	4-24
4.7	Air Quality Impacts of Cylinder Preparation Options at the Paducah Site	4-29
4.8	Summary of Environmental Parameters for the Cylinder Transfer Facility	4-31

TABLES (Cont.)

4.9	Potential Socioeconomic Impacts of the Cylinder Preparation Options at the Paducah Site	4-34
4.10	Potential Impacts to Ecological Resources from Construction of the Cylinder Transfer Facility at the Paducah Site	4-38
4.11	Potential Impacts to Ecological Resources from Operation of the Cylinder Transfer Facility at the Paducah Site	4-39
4.12	Waste Generated from Activities Associated with Cylinder Overcontainers or Standard Cylinder Preparation	4-40
4.13	Total Wastes Generated during Construction of a Cylinder Transfer Facility at the Paducah Site	4-41
4.14	Estimated Annual Radioactive, Hazardous, and Nonhazardous Wastes Generated during Operation of the Cylinder Transfer Facility at the Paducah Site	4-42
4.15	Resource Requirements for Construction and Operation of the Cylinder Transfer Facility at the Paducah Site	4-44
5.1	Summary of the Conversion Options Considered for Each Programmatic Management Alternative	5-2
5.2	Summary of Conversion Option Impacts for the Paducah Site	5-5
5.3	Summary of Technologies Considered under Each Conversion Option	5-11
5.4	Radiological Doses from Conversion/Treatment Options under Normal Operations at the Paducah Site	5-17
5.5	Latent Cancer Risks from Conversion/Treatment Options under Normal Operations at the Paducah Site	5-18
5.6	Chemical Impacts to Human Health for Conversion/Treatment Options under Normal Operations at the Paducah Site	5-23
5.7	Accidents Considered for the Conversion Options	5-24
5.8	Estimated Radiological Doses per Accident Occurrence for the Conversion Options for the Paducah Site	5-32
5.9	Estimated Radiological Health Risks per Accident Occurrence for the Conversion Options for the Paducah Site	5-33

TABLES (Cont.)

5.10	Number of Persons with Potential for Adverse Effects from Accidents under the Conversion Options for the Paducah Site	5-34
5.11	Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Conversion Options for the Paducah Site	5-35
5.12	Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Conversion Options	5-38
5.13	Emissions to the Atmosphere from Construction of a Depleted UF_6 Conversion Plant during the Peak Year	5-39
5.14	Maximum 1-Hour Average Pollutant Concentrations at the Nearest Point on the Boundary from Construction of a Conversion Facility at the Paducah Site	5-40
5.15	Maximum Air Quality Impacts from Conversion Facility Construction at the Paducah Site	5-40
5.16	Air Quality Impacts from Construction of the Cylinder Treatment Facility	5-41
5.17	Emissions to the Atmosphere from Operation of a Depleted UF_6 Conversion Plant	5-42
5.18	Air Quality Impacts from Operations for Conversion to U_3O_8 at the Paducah Site	5-43
5.19	Air Quality Impacts from Operations for Conversion to UO_2 at the Paducah Site	5-44
5.20	Air Quality Impacts from Operations for Conversion to Uranium Metal at the Paducah Site	5-45
5.21	Summary of Conversion Option Parameters Affecting Water Quality and Soil	5-47
5.22	Summary of Environmental Parameters for the Cylinder Treatment Facility	5-50
5.23	Potential Socioeconomic Impacts of the Conversion Options for the Paducah Site	5-55
5.24	Impacts to Ecological Resources from Construction of a Conversion Facility and Cylinder Treatment Facility	5-59

TABLES (Cont.)

5.25	Wastes Generated from Construction and Operations Activities for Depleted UF ₆ Conversion	5-64
5.26	Annual Waste Generation during Operation of the Cylinder Treatment Facility	5-68
5.27	Resource Requirements for Constructing a Conversion Facility	5-69
5.28	Resource Requirements for Operating a Conversion Facility	5-71
5.29	Land Requirements for the Conversion Options	5-72
6.1	Summary of Depleted Uranium Chemical Forms and Storage Options Considered	6-2
6.2	Summary of Long-Term Storage Option Impacts for the Paducah Site	6-4
6.3	Radiological Doses from Long-Term Storage Options under Normal Operations	6-18
6.4	Latent Cancer Risks from Long-Term Storage Options under Normal Operations	6-19
6.5	Chemical Impacts to Human Health for Long-Term Storage Options under Normal Operations	6-21
6.6	Accidents Considered for the Long-Term Storage Options	6-23
6.7	Estimated Radiological Doses per Accident Occurrence for the Long-Term Storage Options at the Paducah Site	6-26
6.8	Estimated Radiological Health Risks per Accident Occurrence for the Long-Term Storage Options at the Paducah Site	6-27
6.9	Number of Persons with Potential for Adverse Effects from Accidents under the Long-Term Storage Options at the Paducah Site	6-28
6.10	Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Long-Term Storage Options at the Paducah Site	6-29
6.11	Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Long-Term Storage Options	6-32

TABLES (Cont.)

6.12	Maximum 1-Hour Pollutant Concentrations at Paducah Site Boundaries as a Result of Long-Term Storage Facility Construction Emissions under Worst-Case Meteorological Conditions	6-33
6.13	Maximum Pollutant Concentrations at Facility Boundaries from Operations Emissions during Long-Term Storage	6-34
6.14	Maximum Pollutant Concentrations at Facility Boundaries during Operations for the Long-Term Storage of Depleted UF ₆ in Yards	6-34
6.15	Summary of Environmental Parameters for Long-Term Storage in Buildings	6-36
6.16	Summary of Environmental Parameters for Long-Term Storage in Vaults	6-38
6.17	Potential Socioeconomic Impacts of the Long-Term Storage Options for Yards, Buildings, and Vaults at the Paducah Site	6-43
6.18	Impacts to Ecological Resources from Construction of Long-Term Storage Facilities for Depleted Uranium	6-47
6.19	Estimated Annual Waste Loads from Long-Term Storage of UF ₆ in Yards	6-51
6.20	Estimated Total Wastewater Volumes from Construction of Long-Term Storage Facilities for UF ₆ , U ₃ O ₈ , and UO ₂	6-52
6.21	Annual Waste Loads from Long-Term Storage of UF ₆ , U ₃ O ₈ , and UO ₂ in Buildings and Vaults	6-53
6.22	Resource Requirements for Constructing UF ₆ , U ₃ O ₈ , and UO ₂ Storage Facilities	6-55
6.23	Resource Requirements for Operating UF ₆ , U ₃ O ₈ , and UO ₂ Storage Facilities	6-56
6.24	Land Requirements for the Long-Term Storage Options	6-57
7.1	Cumulative Impacts of Depleted UF ₆ Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Paducah Site, 1999 through 2039	7-5
8.1	Specific Options and Parametric Cases Analyzed in Detail for the Paducah Site	8-3
8.2	Waste Generation from Conversion Facilities for 100%, 50%, and 25% Throughput Cases	8-26

FIGURES

2.1	Regional Map of the Paducah Site Vicinity	2-2
2.2	Locations of Cylinder Yards at the Paducah Site That Are Used to Store DOE Cylinders	2-4
2.3	Locations of Contaminated Groundwater Plumes at the Paducah Site	2-12
2.4	Distribution of Minority and Low-Income Census Tracts within a 50-Mile Radius of the Paducah Site	2-23
4.1	Horizontal “Clamshell” Overcontainer for Transportation of Cylinders Not Meeting DOT Requirements	4-9
4.2	Representative Layout of a Transfer Facility Site	4-10
4.3	Annual Collective Dose to Involved Workers at the Paducah Site from Preparing Problem Cylinders for Shipment Using Overcontainers	4-12
4.4	Estimated Annual Collective Dose to Involved Workers at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology	4-12
4.5	Annual Collective Dose to Involved Workers at the Paducah Site from Preparing Standard Cylinders for Shipment	4-13
4.6	Estimated Annual Collective Dose to Noninvolved Workers at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology	4-13
4.7	Estimated Annual Dose to the Noninvolved Worker MEI at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology	4-14
4.8	Estimated Annual Collective Dose to the General Public at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology	4-14
4.9	Estimated Annual Dose to the General Public MEI at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology	4-15
4.10	Worker Fatality and Injury Incidence for Cylinder Overcontainer Activities	4-26
4.11	Worker Fatality Incidence for Cylinder Transfer Activities	4-27

FIGURES (Cont.)

4.12	Worker Injury Incidence for Cylinder Transfer Activities	4-27
4.13	Worker Fatality and Injury Incidence for Standard Cylinder Preparation	4-27
5.1	Representative Site Layout for a Conversion Facility	5-3
8.1	Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to U_3O_8	8-5
8.2	Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to U_3O_8	8-5
8.3	Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to U_3O_8	8-6
8.4	Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to U_3O_8	8-6
8.5	Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to U_3O_8	8-7
8.6	Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to U_3O_8	8-7
8.7	Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to UO_2	8-9
8.8	Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to UO_2	8-9
8.9	Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to UO_2	8-10
8.10	Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to UO_2	8-10
8.11	Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to UO_2	8-11
8.12	Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to UO_2	8-11
8.13	Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to Uranium Metal	8-12

FIGURES (Cont.)

8.14	Estimated Annual Dose to the General Public MEI from the Conversion of UF ₆ to Uranium Metal	8-12
8.15	Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF ₆ to Uranium Metal	8-13
8.16	Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF ₆ to Uranium Metal	8-13
8.17	Estimated Annual Collective Dose to Involved Workers from the Conversion of UF ₆ to Uranium Metal	8-14
8.18	Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF ₆ to Uranium Metal	8-14
8.19	Estimated Annual Collective Dose to Members of the Public from the Cylinder Treatment Facility	8-15
8.20	Estimated Annual Dose to the General Public MEI from the Cylinder Treatment Facility	8-15
8.21	Estimated Annual Collective Dose to Noninvolved Workers from the Cylinder Treatment Facility	8-16
8.22	Estimated Annual Dose to the Noninvolved Worker MEI from the Cylinder Treatment Facility	8-16
8.23	Estimated Annual Collective Dose to Involved Workers from the Cylinder Treatment Facility	8-17
8.24	Estimated Annual Average Individual Dose to Involved Workers from the Cylinder Treatment Facility	8-17
8.25	Estimated Number of On-the-Job Injuries for the Conversion of UF ₆ to U ₃ O ₈	8-21
8.26	Estimated Number of On-the-Job Injuries for the Conversion of UF ₆ to UO ₂	8-21
8.27	Estimated Number of On-the-Job Injuries for the Conversion of UF ₆ to Uranium Metal	8-22
8.28	Estimated Number of On-the-Job Injuries for the Cylinder Treatment Facility	8-22
8.29	Estimated Annual Collective Dose to Involved Workers from Storage as UF ₆	8-31

FIGURES (Cont.)

8.30	Estimated Annual Average Individual Dose to Involved Workers from Storage as UF_6	8-31
8.31	Estimated Annual Collective Dose to Involved Workers from Storage as UO_2	8-32
8.32	Estimated Annual Average Individual Dose to Involved Workers from Storage as UO_2	8-32
8.33	Estimated Annual Collective Dose to Involved Workers from Storage as U_3O_8	8-33
8.34	Estimated Annual Average Individual Dose to Involved Workers from Storage as U_3O_8	8-33
8.35	Estimated Number of On-the-Job Injuries for Storage as UF_6	8-36
8.36	Estimated Number of On-the-Job Injuries for Storage as UO_2	8-36

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NOTATION

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
AQCR	Air Quality Control Region
BEA	U.S. Bureau of Economic Analysis
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CFR	<i>Code of Federal Regulations</i>
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EBE	evaluation-basis earthquake
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
HAP	hazardous air pollutant
HEPA	high-efficiency particulate air (filter)
KAR	<i>Kentucky Administrative Regulations</i>
K _d	distribution coefficient
KDEP	Kentucky Department of Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
LCF	latent cancer fatality
LLMW	low-level mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
LMES	Lockheed Martin Energy Systems, Inc.
MCL	maximum contaminant level
MEI	maximally exposed individual
MMES	Martin Marietta Energy Systems, Inc.
MOA	memorandum of agreement
NAAQS	National Ambient Air Quality Standards
NCRP	National Council on Radiation Protection and Measurements
NEPA	<i>National Environmental Policy Act of 1969</i>
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration

PEIS	programmatic environmental impact statement
PEL	permissible exposure limit
PGDP	Paducah Gaseous Diffusion Plant
PM ₁₀	particulate matter with a mean diameter of 10 : m or less
RCRA	<i>Resource Conservation and Recovery Act</i>
ROD	Record of Decision
ROI	region of influence
SAR	safety analysis report
TSCA	<i>Toxic Substances Control Act</i>
USEC	United States Enrichment Corporation
VOC	volatile organic compound

Chemicals

AlF ₃	aluminum trifluoride
CaF ₂	calcium fluoride
CO	carbon monoxide
Fe	iron
HC	hydrocarbons
HF	hydrogen fluoride
HNO ₃	nitric acid
Mg	magnesium
MgF ₂	magnesium fluoride
NaOH	sodium hydroxide
NO _x	nitrogen oxides
O ₃	ozone
Pb	lead
PCB	polychlorinated biphenyl
SO _x	sulfur oxides
TCE	trichloroethylene
UF ₄	uranium tetrafluoride
UF ₆	uranium hexafluoride
UO ₂	uranium dioxide
U ₃ O ₈	triuranium octaoxide (uranyl uranate)
UO ₂ F ₂	uranyl fluoride
UO ₂ (OH) ₂	uranyl hydroxide

UNITS OF MEASURE

EF	degree(s) Fahrenheit	m ²	square meter(s)
Ci	curie(s)	m ³	cubic meter(s)
cm	centimeter(s)	mg	milligram(s)
cm ³	cubic centimeter(s)	min	minute(s)
d	day(s)	mrem	millirem(s)
ft	foot (feet)	MW	megawatt(s)
ft ²	square foot (feet)	MWh	megawatt hour(s)
ft ³	cubic foot (feet)	MWyr	megawatt year(s)
g	gram(s)	pCi	picocurie(s)
gal	gallon(s)	ppb	part(s) per billion
gpm	gallon(s) per minute	ppm	part(s) per million
GWh	gigawatt hour(s)	psia	pound(s) per square inch absolute
ha	hectare(s)	rad	radiation absorbed dose(s)
in.	inch(es)	rem	roentgen equivalent man
kg	kilogram(s)	s	second(s)
km	kilometer(s)	scf	standard cubic foot (feet)
L	liter(s)	scm	standard cubic meter(s)
lb	pound(s)	ton(s)	short ton(s)
μg	microgram(s)	yd ²	square yard(s)
m	meter(s)	yd ³	cubic yard(s)
		yr	year(s)

**DEPLETED URANIUM HEXAFLUORIDE MANAGEMENT PROGRAM:
DATA COMPILATION FOR THE PADUCAH SITE**

**in Support of Site-Specific NEPA Requirements for Continued
Cylinder Storage, Cylinder Preparation, Conversion, and
Long-Term Storage Activities**

Compiled by
H.M. Hartmann

ABSTRACT

This report is a compilation of data and analyses for the Paducah site, near Paducah, Kentucky. The data were collected and the analyses were done in support of the U.S. Department of Energy (DOE) 1999 *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE/EIS-0269). The report describes the affected environment at the Paducah site and summarizes potential environmental impacts that could result from conducting the following depleted uranium hexafluoride (UF₆) activities at the site: continued cylinder storage, preparation of cylinders for shipment, conversion, and long-term storage. DOE's preferred alternative is to begin converting the depleted UF₆ inventory as soon as possible to either uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

1 INTRODUCTION AND BACKGROUND

This report is a compilation of data and analyses for the Paducah site, which were obtained and conducted to prepare the *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (U.S. Department of Energy [DOE] 1999a; hereafter referred to as the PEIS). The PEIS examines alternative management strategies for the long-term storage, use, and disposal of the nation's depleted uranium hexafluoride (UF₆) inventory that falls under the responsibility of DOE. This inventory currently amounts to approximately 700,000 metric tons of depleted UF₆, containing about 476,000 metric tons of uranium. It is stored at three sites: the Paducah site in Kentucky, Portsmouth site in Ohio, and East Tennessee Technology Park in Tennessee. (East Tennessee Technology Park is referred to by its original name, the K-25 site, throughout this report.) The inventory is stored in about 57,700 steel cylinders and includes about 11,200 cylinders of material that have been or will

be transferred to DOE from the United States Enrichment Corporation (USEC) under two recent memorandums of agreement (MOAs). Approximately 60% of the above inventory is stored at the Paducah site.

The PEIS examines six alternative management strategies (also termed “alternatives”). These strategies include a no action alternative (indefinite, continued storage of the depleted UF₆ at the current storage sites) and five action alternatives (long-term storage as UF₆, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal). Each of the alternatives would involve some combination of seven activities: continued cylinder storage at the current storage sites, cylinder preparation for shipment, conversion to another chemical form, long-term storage, manufacture and use, disposal, and transportation. This report presents Paducah site-specific data from the PEIS for continued storage, cylinder preparation, conversion, and long-term storage activities, as well as data on the existing environment and cumulative impacts at the site.

Under the scope of the current Depleted UF₆ Management Program, additional National Environmental Policy Act (NEPA) documents or environmental information may be required for certain activities. These activities include (1) transporting depleted UF₆ cylinders from one or more of the current storage sites to a site or sites selected for conversion, (2) constructing and operating conversion facilities, (3) constructing additional storage capacity at one or more of the current storage sites, and (4) developing the environmental data required for procurement actions. This report documents the information and results of analyses already obtained and conducted for the Paducah site during the preparation of the PEIS, which can serve as a starting point for preparation of site-specific NEPA analyses. This report’s compilation of data should provide background for and expedite subsequent environmental assessment and procurement tasks needed to implement the strategy selected in the *Record of Decision for Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE 1999b). However, the data will not be sufficient to completely fulfill NEPA requirements for analyzing conversion or long-term storage activities at the Paducah site; more specific information (e.g., process design, activity locations within the site, effluent amounts) will be required for the site-specific NEPA analyses.

The PEIS presents data on the existing environment at the three current storage sites. The information covers ambient air quality, geology and soil, water resources, biotic resources, public and occupational health and safety, socioeconomics, waste management, cultural resources, and the prevalence of minority and low-income populations. These data are presented in Section 2 of this report specifically for the Paducah site.

All of the strategies examined in the PEIS consider the impacts that could result from the continued storage of cylinders at the three current storage sites for some period of time. In addition, because strategies involving the transportation of the cylinders from their current locations for conversion or long-term consolidated storage would involve the preparation of the cylinders for shipment, the PEIS also reviews the site-specific impacts that could result from cylinder preparation

at each of the three sites. The impacts of continued cylinder storage presented in the PEIS are presented in Section 3 of this report specifically for the Paducah site. The impacts of cylinder preparation at the Paducah site are discussed in Section 4.

In the PEIS, the analyses of the conversion and long-term storage options assumed that the three current storage sites were representative of sites that might actually be used for these activities. Analyses were conducted by using site-specific data (e.g., worker and off-site population distribution, meteorological conditions) for each of the three current storage sites. After the analyses were completed, the results were aggregated and presented as a range that accounted for differences in the sites as well as differences in the technologies that might be used in the future. In this report, ranges of impacts from the different conversion technologies examined in the PEIS are presented in Section 5 specifically for the Paducah site. The ranges of impacts from the various long-term storage options examined in the PEIS are presented specifically for the Paducah site in Section 6.

Section 7 of this report presents the results of cumulative impact analyses conducted for the Paducah site as part of the PEIS. Section 8 gives the results of parametric analyses conducted for conversion and long-term storage at the Paducah site. Parametric analyses were included in the PEIS to illustrate the differences in potential environmental impacts if facility capacities were smaller than those assumed for the full-scale analyses. Finally, references are given in Section 9.

The final PEIS included impact analyses for the management of 46,422 cylinders that were filled by DOE before July 1, 1993 (the date USEC took over the operation of the gaseous diffusion plants), and up to an additional 15,000 cylinders generated by USEC (see Chapters 2 and 6 of the PEIS). The impacts that the additional USEC cylinders would have on continued storage, cylinder preparation, conversion, and long-term storage are considered in Sections 3.5, 4.5, 5.5, and 6.5 of this document. The number of original DOE cylinders stored at Paducah is 28,351. The number of USEC cylinders that have been or will be transferred to DOE is 8,559. However, for the purpose of analysis, the PEIS assumed that the number of cylinders to be transferred from USEC to DOE at the Paducah site would be 12,000.

The detailed methodologies used to conduct the environmental impact assessments presented in this report are documented in Appendix C of the PEIS and in various backup reports to the PEIS. It is beyond the scope of this report to provide the detailed descriptions of methods presented in these other reports; they are referenced as necessary.

2 AFFECTED ENVIRONMENT

Depleted UF₆ is currently managed at three locations: the Paducah site, Portsmouth site, and K-25 site. The PEIS and this report distinguish the site (the entire DOE facility) from the gaseous diffusion plant (a facility operated by USEC within the larger site) and from the storage yards (the location of the depleted UF₆ cylinders within the site). This section describes the affected environment at the Paducah site.

The Paducah site is located in rural McCracken County, Kentucky, approximately 10 miles (16 km) west of the city of Paducah and 3.6 miles (6 km) south of the Ohio River (Figure 2.1). The Paducah site includes 3,423 acres (1,386 ha) surrounded by an additional 2,781 acres (1,125 ha) owned by DOE but managed by the State of Kentucky as part of the West Kentucky Wildlife Management Area (Martin Marietta Energy Systems, Inc. [MMES] 1994a). According to a 1953 agreement granting the land to the Kentucky Department of Fish and Wildlife Resources, DOE can use any or all of this land whenever the need arises (MMES 1990). The city of Paducah is the largest urban area in the six counties surrounding the site. The six-county area is primarily rural, with industrial uses accounting for less than 5% of land use.

The Paducah Gaseous Diffusion Plant (PGDP) occupies a 750-acre (303-ha) complex within the Paducah site and is surrounded by a security fence (Figure 2.1). The PGDP, previously operated by DOE and now operated by USEC, includes 115 buildings with a combined floor space of approximately 8.2 million ft² (0.76 million m²) (MMES 1990). The PGDP has operated since 1955.

In 1994, the Paducah site was placed on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL), a list of sites across the nation that have been designated by the EPA as high priority for site remediation. The NPL designation was mainly a result of groundwater contamination with trichloroethylene (TCE) and technetium-99, first detected in 1988. Being placed on the NPL meant that the cleanup requirements of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) would be met in conducting remediation efforts at the Paducah site. Hazardous waste and mixed waste management at the Paducah site must comply with *Resource Conservation and Recovery Act* (RCRA) regulations, which are administered by the Commonwealth of Kentucky, Division of Waste Management. The RCRA regulations also address implementation of corrective (or remedial) actions for solid waste management units. Thus, both CERCLA and RCRA have requirements for remedial actions for contaminated environmental media. A Federal Facilities Agreement (FFA) has been developed to integrate CERCLA/RCRA requirements into a single remediation procedure for the Paducah site.

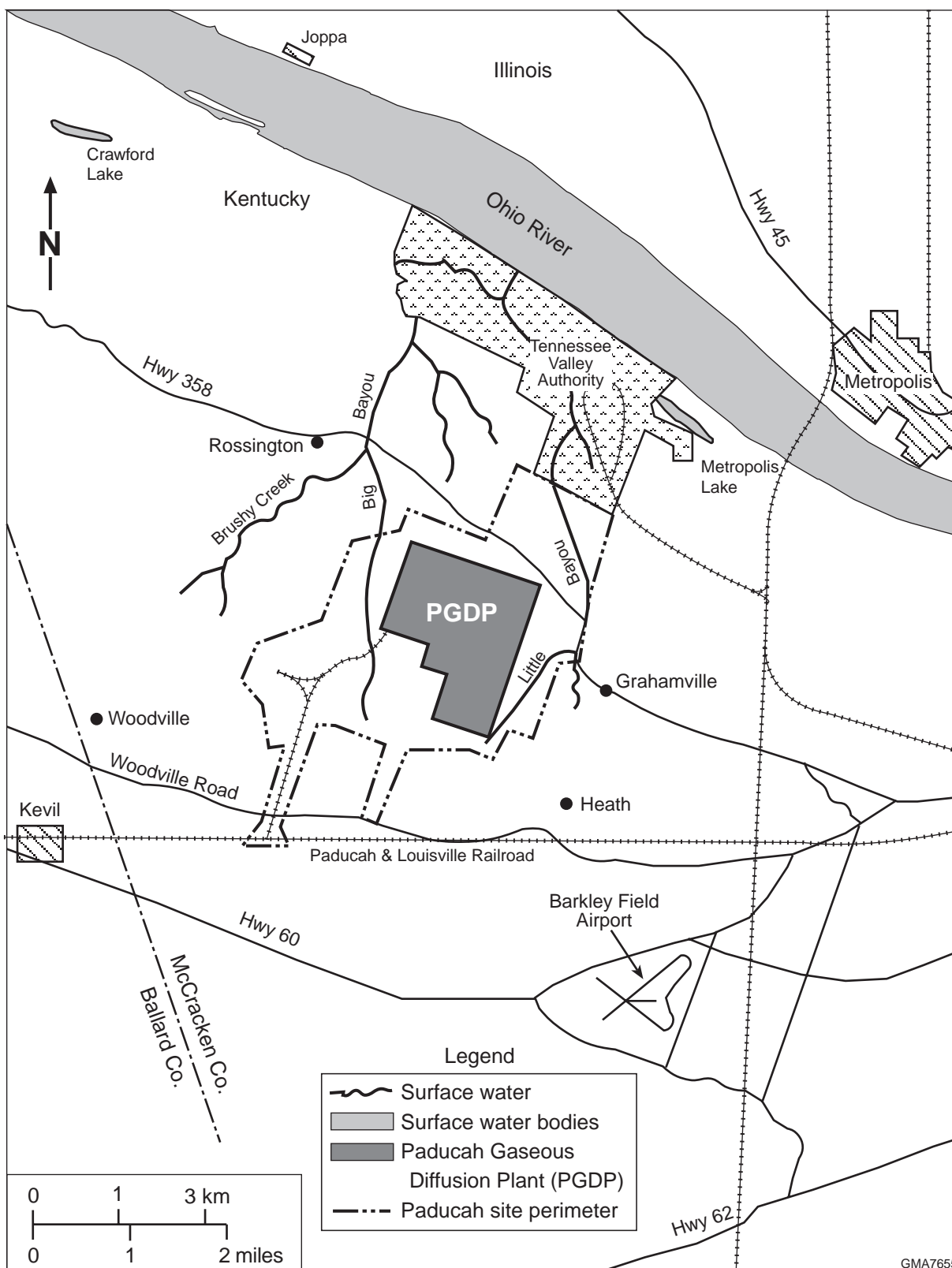


FIGURE 2.1 Regional Map of the Paducah Site Vicinity (Source: Adapted from Lockheed Martin Energy Systems, Inc. [LMES] 1996)

The discussion of the affected environment in this section focuses on conditions and contaminants pertinent to depleted UF₆ cylinder management. Some sitewide information from ongoing CERCLA/RCRA investigations is also included to put environmental conditions in the current depleted UF₆ cylinder storage areas into the context of sitewide conditions.

2.1 CYLINDER YARDS

The Paducah site has 13 yards used to store cylinders of DOE-generated depleted UF₆ (Table 2.1; Figure 2.2). The yards encompass approximately 13 acres (5.3 ha) and store 28,351 cylinders containing depleted UF₆. Nine of the Paducah storage yards have gravel bases. The C-745-F yard (F-yard) is located on a former building foundation. The C-745-S yard (S-yard), C-745-G yard (G-yard), and C-745-T yard (T-yard) are newly constructed with concrete bases. The C-745-T (T-yard) was originally constructed outside the PGDP boundary but within the site perimeter. The PGDP boundary and fencing have been expanded to include the T-yard. The remaining cylinder yards will be rebuilt with concrete bases, starting with the C-745-K, C-745-L, C-745-M, C-745-N, and C-745-P yards (K-, L-, M-, N-, and P-yards). Cylinders are being restacked during relocation onto the newly constructed yards.

In addition to the DOE-generated cylinders, approximately 6,600 USEC-generated cylinders are stored in yards C-745-C, E, Q, and R (see Figure 2.2; DOE and USEC 1998a). Cylinder yard C-745-E is actually a cylinder staging area where cylinders are stored only temporarily; the USEC cylinders in this yard will be moved to C-745-Q or -R yards. The three yards C-745-C, Q, and R have gravel bases. Reconstruction of these yards with concrete bases is planned to follow the completion of reconstruction of the gravel yards currently storing DOE-generated cylinders (DOE and USEC 1998a). On the basis of a

TABLE 2.1 Locations of Cylinders of DOE-Generated Depleted UF₆ at the Paducah Site^a

Yard	Area (ft ²)	Number of Cylinders
C-745-A ^b	199,899	1,802
C-745-B ^b	471,630	1,185
C-745-C	439,902	227
C-745-D	47,628	401
C-745-F	156,000	4,090
C-745-G	405,000	5,733
C-745-K	180,000	4,023
C-745-L	312,000	4,624
C-745-M	120,000	902
C-745-N	180,000	1,629
C-745-P	96,000	1,735
C-745-S	130,000	2,000
C-745-T	485,600	0
Total		28,351

^a Locations of cylinders as of May 1996.

^b USEC-leased yard with DOE cylinders in storage.

Source: Cash (1996).

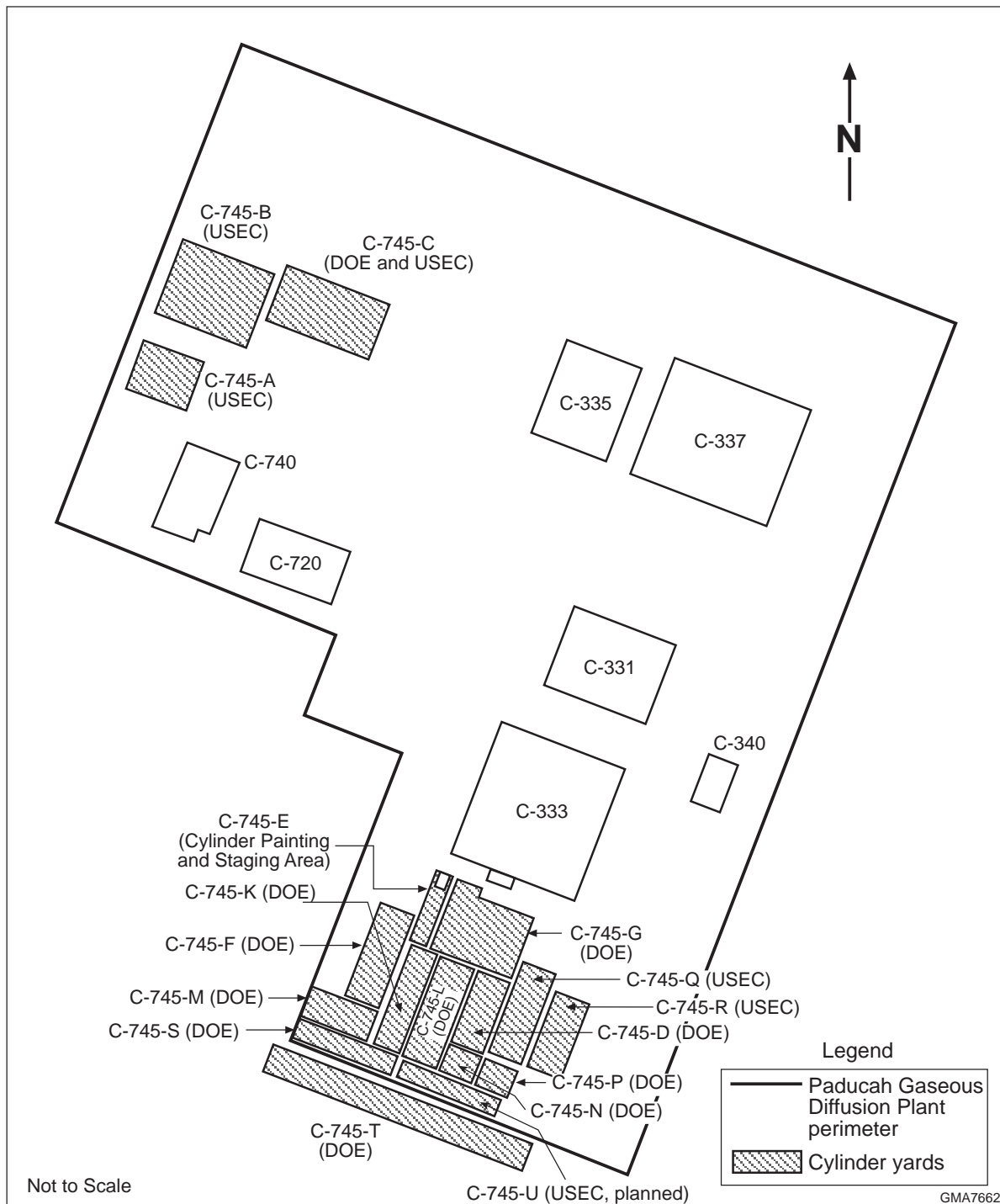


FIGURE 2.2 Locations of Cylinder Yards at the Paducah Site That Are Used to Store DOE Cylinders (Source: Adapted from DOE 1995 and Cash 1997)

June 1998 MOA, ownership and management of approximately 2,000 additional cylinders will be transferred from USEC to DOE between 1999 and 2004 (DOE and USEC 1998b). For purposes of analysis, it is assumed that these cylinders will be located in yards C-745-C, Q, or R at the Paducah site.

One breached cylinder was identified in F-yard in November 1992. The small hole (about $1/16 \times 2$ in. [0.16×5 cm]) was attributed to handling damage, and a permanent patch was subsequently applied. In 1996, a steel engineered patch was welded onto another cylinder at the Paducah site. No material was thought to have been lost from either of these cylinders.

2.2 SITE INFRASTRUCTURE

The Paducah site is located in an area with an established transportation network. The area is served by two interstate highways, several U.S. and state highways, several rail lines, and a regional airport.

All water used by the site is obtained from the Ohio River through an intake at the steam plant near the Shawnee Power Plant north of the site. Before use, the water is treated on-site. Current water usage is approximately 15 million gal/d (57 million L/d). The maximum site capacity is 30 million gal/d (115 million L/d) (DOE 1996).

Electric Energy, Inc., supplies electric power to the Paducah site. The current electrical need is 1,564 MW, with a maximum capacity of 3,040 MW. The coal system uses 82 tons (74 metric tons) per day, with a maximum capacity of 180 to 200 tons (160 to 180 metric tons) (DOE 1996).

2.3 AMBIENT AIR QUALITY AND AIRBORNE EMISSIONS

The affected environment for air quality at the Paducah site is generally considered to be the EPA-defined Air Quality Control Region (AQCR). The Paducah (Kentucky)-Cairo (Illinois) Interstate AQCR in EPA Region 4 includes McCracken County, Kentucky, in which the Paducah site is located. The EPA classifies McCracken County as an attainment area for all six National Ambient Air Quality Standards (NAAQS) criteria pollutants: carbon monoxide (CO), sulfur oxides (SO_x), particulate matter (PM₁₀, particles with a mean diameter of 10 : m or less), ozone (O₃), nitrogen oxides (NO_x), and lead (Pb). An attainment area for a criteria pollutant is an area that has an ambient air concentration of the pollutant below the corresponding standard.

The Commonwealth of Kentucky has adopted ambient air quality standards that specify maximum permissible short-term and long-term concentrations of various contaminants (Table 2.2). These standards are generally the same as the national standards. In addition to standards for criteria

TABLE 2.2 Kentucky Ambient Air Quality Standards^a

Pollutant	Primary Standard	Secondary Standard
Carbon monoxide (CO)		
1-hour average	35 ppm ^b	35 ppm
8-hour average	9 ppm ^b	9 ppm
Sulfur oxides (SO _x)		
3-hour average	— ^c	0.50 ppm ^b
24-hour average	0.14 ppm ^b	—
Annual average	0.03 ppm	—
Particulate matter (PM ₁₀)		
24-hour average	150 : g/m ³	150 : g/m ³
Annual arithmetic mean	50 : g/m ³	50 : g/m ³
Ozone (O ₃)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen oxides (NO _x)		
Annual average	0.05 ppm	0.05 ppm
Lead (Pb)		
Quarterly average	1.5 : g/m ³	1.5 : g/m ³
Hydrogen sulfide		
Maximum 1-hour average	—	14 : g/m ³ (0.01 ppm) ^a
Gaseous fluorides (as hydrogen fluoride [HF])		
Annual arithmetic mean, not to exceed	0.5 ppm	—
Maximum 1-month average	—	1.00 ppb ^b
Maximum 1-week average	—	2.00 ppb ^b
Maximum 24-hour average	1.0 ppm ^b	3.50 ppb ^b
Maximum 12-hour average	—	4.50 ppb ^b
Total fluorides ^e		
Average concentration of monthly samples over growing season (not to exceed 6 consecutive months)	—	40 ppm (w/w)
2-month average	—	60 ppm (w/w)
1-month average	—	80 ppm (w/w)
Odors	At any time when one volume unit of ambient air is mixed with seven volume units of odorless air, the mixture must have no detectable odor.	

^a ppb = parts per billion, ppm = parts per million, w/w = weight for weight.

^b Average not to be exceeded more than once per year.

^c A hyphen (-) indicates no standard is available for this averaging period.

^d Standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 : g/m³, as determined in accordance with Appendix K of 40 CFR Part 50, is equal to or less than one.

^e Concentrations not to be exceeded on a dry weight basis (as fluoride ion) in and on forage for consumption by grazing ruminants.

Source: DOE (1996).

pollutants, the Kentucky Department of Environmental Protection (KDEP) has adopted rules governing new or modified sources emitting toxic air pollutants (“General Standards of Performance,” *Kentucky Administrative Regulations*, Title 401, Chapter 63, Regulation 022 [401 KAR 63:022]), as well as standards for the hazardous air pollutants (HAPs) regulated by the National Emission Standards for Hazardous Air Pollutants (NESHAP) (*Code of Federal Regulations*, Title 40, Part 61 [40 CFR Part 61]).

DOE has responsibility for four air emission sources at the Paducah site, none of which involve the release of radiological effluents. The Paducah site is not required to conduct ambient air monitoring. DOE activities at the site in 1996 released quantities of criteria and HAPs well below the amounts that would cause them to be classified by the *Clean Air Act* as a major source (LMES 1997c). An aggregate emission of 100 tons of any single criteria pollutant is required for the DOE operations to be classified as a major source. Emissions of criteria pollutants from cylinder refurbishment (grit blasting and painting) amounted to about 4.5 tons of particulate and 3.4 tons of volatile organic compounds (VOCs). Another 12 tons of VOCs may have been released from inactive closed landfills. In all, a total of as much as 16.6 tons of VOCs may have been emitted. The largest source of HAPs, a contaminated groundwater treatment facility, produced 1.4 tons of trichloroethylene, compared with the 10 tons of emissions of a single HAP necessary for major source designation.

2.4 GEOLOGY AND SOIL

2.4.1 Topography, Structure, and Seismic Risk

The topography of the Paducah site is relatively flat; within the boundaries of the PGDP security fence, the maximum difference in elevation is about 10 ft (3 m) (ERC/EDGE 1989). The site is underlain by bedrock of limestone and shale. Several zones of faulting occur in the vicinity of the site (Argonne National Laboratory [ANL] 1991).

The largest recorded earthquake in the region occurred in 1812 and was centered in the New Madrid fault zone. This earthquake had a magnitude of 7.3, and the epicenter was 60 miles (96 km) southwest of the site (LMES 1997b). This earthquake completely destroyed the town of New Madrid, Missouri.

The seismic hazards at the Paducah site have been studied extensively. The safety analysis report (SAR) for this site, completed in March 1997, provided comprehensive analyses and discussions of seismic hazards at the site (see Sections 1.5 and 3.3 of the SAR; LMES 1997b). The analyses considered the possibility of large-magnitude earthquakes similar to the New Madrid earthquakes of 1811–1812. The analyses performed by DOE were independently reviewed by the

U.S. Geological Survey (USGS). The independent review by the USGS indicated that the seismic sources, recurrence rates, maximum magnitudes, and the attenuation functions used in the SAR analyses were representative of a wide range of professional opinion and were suitable for obtaining probabilistically based seismic hazard estimates. Because of the proximity of the site to the New Madrid seismic zone, special deterministic analyses were also performed to estimate the ground motions at the site in the case of recurrence of an earthquake of the same magnitude as the 1811–1812 New Madrid earthquakes. The results of the deterministic analyses were similar to the probabilistic seismic hazard results for the probabilities associated with the recurrence of the New Madrid earthquakes of 1811–1812. The results also indicated that continued storage of depleted UF₆ cylinders at the Paducah site is safe.

For the Paducah site, the evaluation basis earthquake (EBE) was designated by DOE to have a return period of 250 years. A detailed analysis indicated that the peak ground motion for the EBE was 0.15 times the acceleration of gravity (LMES 1997b). An earthquake of this size would have an equal probability of occurring any time during a 250-year period.

For this report and the PEIS, the analyses of earthquake-initiated accidents at the Paducah site were based on the analyses and results provided in the SAR (LMES 1997b). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered.

2.4.2 Soil

Substances in soil possibly associated with cylinder management activities would be uranium and fluoride compounds, which could be released if breached cylinders or faulty valves were present. For the evaluation of ongoing activities at the Paducah site, the purpose of soil sampling has been to identify the accumulation of any airborne pollutants; thus, annual soil samples have been collected from 10 off-site locations: four at the site boundary, four at distances of 5 miles (8 km) beyond the boundary, and two at more remote locations to characterize background levels (LMES 1996; MMES 1994a). In 1994, uranium concentrations for the 10 sampling locations ranged from 2.0 to 5.8 : g/g; plant boundary concentrations ranged from 2.3 to 4.9 : g/g (LMES 1996).

Because of a transfer of responsibility for air point sources from DOE to USEC, concentrations of nonradiological parameters in soil at these sampling locations are no longer reported (LMES 1996); however, analytical results for polychlorinated biphenyls (PCBs) and metals are available for previous years. In 1993, no detectable concentrations of PCBs were found in any of the samples, but elevated concentrations of bismuth, lead, manganese, thallium, and thorium were

detected in several samples (MMES 1994a). Fluoride was not analyzed in soil samples, but it is naturally occurring in soils and of low toxicity.

As part of ongoing CERCLA/RCRA investigations of Paducah site operable units, several areas of soil have been identified as contaminated with radionuclides and chemicals such as PCBs and metals. However, this contamination is not associated with the depleted UF₆ cylinder yards, and remediation is being implemented as a part of ongoing CERCLA/RCRA activities at the site.

2.5 WATER RESOURCES

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples have indicated the presence of some contamination resulting from previous gaseous diffusion plant operations.

2.5.1 Surface Water

Big Bayou Creek is located on the west side of the Paducah site and Little Bayou Creek on the east side (Figure 2.1). These two streams join north of the site and discharge to the Ohio River. Flows in Big Bayou Creek and Little Bayou Creek fluctuate greatly as a result of precipitation. During most of the year, flows in both streams are derived primarily from plant effluents. All water used by the site is obtained from the Ohio River through an intake north of the site (ANL 1991).

Most of the liquid effluents from the Paducah site consist of cooling water, although a variety of liquid wastes are produced by activities such as metal finishing, uranium recovery, and facility cleaning (Rogers et al. 1988). In addition to these discharges, a large variety of conventional liquid wastes enter the surface water system, including treated domestic sewage, steam plant wastewater, and coal pile runoff.

All effluent discharges are under the Kentucky Pollutant Discharge Elimination System (KPDES). At the present time, there are a total of 15 outfalls. Ten outfalls are authorized to USEC (KY0102083); five outfalls are authorized to DOE (KY000409). Of the DOE outfalls, three are to Big Bayou Creek and one is to an unnamed tributary of Little Bayou Creek. The average discharge of wastewater to Big Bayou Creek is approximately 4 million gal/d (15 million L/d). The average discharge to the Ohio River through Big Bayou and Little Bayou Creeks is about 4.1 million gal/d (16 million L/d). The average flow in the Ohio River is 1.7×10^{11} gal/d (6.5×10^{11} L/d).

Monitoring of surface water in 1995 and 1996 indicated that the maximum average concentration of uranium was 0.012 mg/L in the downstream portion of Little Bayou Creek (LMES

1997a,c). The maximum average concentration of fluoride was < 0.224 mg/L in the north/south diversion ditch within the PGDP (MMES 1994b). Comparable fluoride data were not reported for 1994, 1995, or 1996 (LMES 1996, 1997a,c).

The KPDES-permitted outfalls are monitored for inorganic substances and about 45 organic substances, including PCBs. The monitoring frequency for most substances is two to four times per year; several substances are monitored monthly or quarterly to comply with KPDES permit requirements. The maximum average uranium concentration in effluents from the DOE outfalls from 1994 through 1996 was 0.037 mg/L (LMES 1996, 1997a,c). In both 1994 and 1995, two USEC-leased outfalls received a “Notice of Violation” for PCB exceedances.

Sediment samples are also collected annually from six locations and analyzed for uranium, PCBs, and metals. In 1993, concentrations of uranium and PCBs were detected at significantly higher levels than background in Little Bayou Creek (sampling location SS2). The uranium concentration of 200 mg/kg at the measuring location was two times higher than in 1992. The PCB concentration also increased from 0.9 mg/kg in 1992 to 2.0 mg/kg in 1993. However, levels decreased in 1994 (22 mg/kg maximum uranium concentration; 1.4 mg/kg maximum PCB concentration) (LMES 1996) and again in 1995 (13 mg/kg maximum uranium concentration; < 0.1 mg/kg maximum PCB concentration) (LMES 1997a). In 1996, the uranium concentration in sediment at location SS2 was 44 mg/kg; the PCB concentration was 1.3 mg/kg. A new sampling location (SS29) was added on Little Bayou Creek closer to the PGDP. The uranium concentration at this location was 360 mg/kg; no PCB value was reported (LMES 1997c).

2.5.2 Groundwater

Two near-surface aquifers are of importance at the Paducah site. The upper aquifer is a shallow, perched-water aquifer composed of sands and sand and clay mixtures that are discontinuous (Rogers et al. 1988). Water yields from this aquifer are very low, and the hydraulic gradient (change in water elevation with distance) is difficult to detect. Water movement is generally in a northeasterly direction at less than 0.1 ft/yr (0.3 m/yr).

The lower aquifer is a good-yielding gravel aquifer that has an upper surface at a depth of about 39 ft (12 m) and a thickness that ranges from about 20 to 59 ft (6 to 18 m). This aquifer appears to be continuous beneath the Paducah site. Hydraulic conductivity is estimated to be 0.0001 to 1 cm/s for the regional gravel aquifer and 0.00001 to 0.01 cm/s for the upper continental deposits (sands). Water movement is 2 to 5 ft/yr (0.6 to 1.5 m/yr) and variable in direction (Rogers et al. 1988).

On-site and off-site groundwater sampling for the Paducah site is performed in about 200 monitoring wells, residential wells, and Tennessee Valley Authority wells. Off-site sampling

is performed to monitor three separate trichloroethylene and technetium plumes first detected in 1988 (LMES 1996) (Figure 2.3). The Paducah site has provided a municipal water supply to all residents whose wells are within the area of groundwater contamination from the site; resident wells that are no longer sampled are locked and capped.

Although the magnitude of groundwater contamination originating from the Paducah site is greatest for trichloroethylene and technetium, the primary drinking water standards or derived concentration guidelines for several other inorganic, volatile organic, and radionuclide substances were also exceeded in one or more of the monitoring wells on or near the Paducah site in monitoring occurring from 1993 through 1996 (MMES 1994b; LMES 1996, 1997a,c). (The derived concentration guideline is equivalent to the maximum contaminant level [MCL]; it is the concentration of a radionuclide that under conditions of continuous exposure for 1 year would result in an effective dose equivalent of 4 mrem [EPA 1996; DOE Order 5400.5].) The uranium guideline of 20 : g/L was exceeded in four wells, and the fluoride guideline of 4 mg/L was exceeded in two wells. The wells with uranium and fluoride exceedances were not located near the cylinder yards.

2.6 BIOTIC RESOURCES

2.6.1 Vegetation

The Paducah site includes the highly developed PGDP, which has few natural vegetation communities. The DOE property between the PGDP and the West Kentucky Wildlife Management Area consists primarily of open, frequently mowed grassy areas. The DOE property also includes several small upland areas of mature forest, old field, and transitional habitats. The banks of Big Bayou Creek and Little Bayou Creek support mature riparian forest with river birch, black willow, and cottonwood (ANL 1991). The West Kentucky Wildlife Management Area contains wooded areas from early and mid-successional stages to mature forest communities. Nonforested areas are managed by controlled burns, mowing, and planting.

2.6.2 Wildlife

The habitats at the Paducah site support a relatively high diversity of wildlife species. Ground-nesting species include the white-footed mouse, bobwhite, and eastern box turtle. Big Bayou Creek, upstream of the Paducah site, supports aquatic fauna indicative of oxygen-rich, clean water, including 14 fish species. Aquatic species just downstream of the Paducah site discharge points include 11 fish species (LMES 1997c). The density and diversity of aquatic organisms are generally lower near the outfalls than upstream areas for both Little Bayou Creek and Big Bayou Creek (DOE 1994).

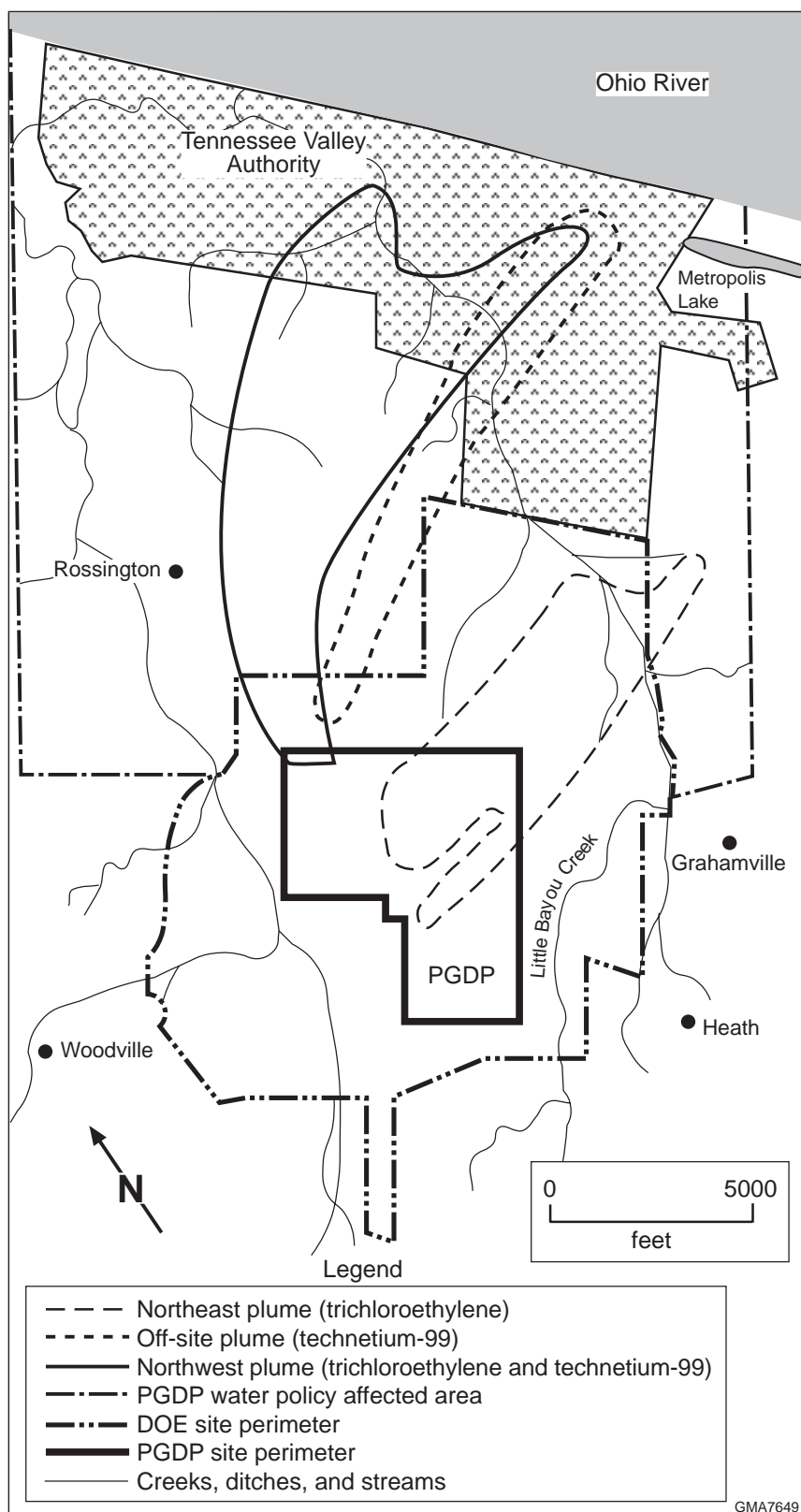


FIGURE 2.3 Locations of Contaminated Groundwater Plumes at the Paducah Site (Source: Adapted from MMES 1994a)

2.6.3 Wetlands

Although no wetlands are identified on the PGDP by the National Wetlands Inventory, approximately 5 acres of jurisdictional wetlands have been identified in drainage ditches scattered throughout the PGDP (ANL 1991; CDM Federal Programs Corporation 1994; Sadri 1995). Outside the PGDP, a large number of wetlands are scattered throughout the Paducah site. These include forested wetlands, ponds, wet meadows, vernal pools, and wetlands converted to agriculture (U.S. Department of the Army 1994c). Palustrine forested wetlands occur extensively along the banks of Big Bayou Creek and Little Bayou Creek. The National Wetlands Inventory identifies many wetlands on the Paducah site, primarily ponds and forested wetlands. A forested wetland dominated by tupelo trees in the West Kentucky Wildlife Management Area has been designated by the Kentucky Nature Preserves Commission and Kentucky Department of Fish and Wildlife as an area of ecological concern (DOE 1996).

2.6.4 Threatened and Endangered Species

No federal-listed plant or animal species are known to occur on the Paducah site. However, the Indiana bat (federal- and state-listed as endangered) has been found near the confluence of Bayou Creek and the Ohio River 3 miles north of the PGDP. Potential habitat occurs on the Paducah site outside the PGDP (U.S. Department of the Army 1994b) and in adjacent wooded areas. State-listed species known to occur on the Paducah site include the compass plant, which is listed by the Kentucky State Nature Preserve Commission as threatened. The lake chubsucker, listed by the Nature Preserve Commission as threatened, is known from early, but not recent, surveys of Big Bayou Creek and Little Bayou Creek. State-listed species of special concern that occur on or near the Paducah site include Bell's vireo, cream wild indigo, and Northern crawfish frog. The presence of state-listed species and requirements for consultation with the Kentucky State Nature Preserve Commission would be determined in site-specific environmental analyses.

2.7 PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY

2.7.1 Radiation Environment

Operations at the Paducah site result in exposures of both on-site workers and off-site members of the general public to radiation (Table 2.3). Exposures of on-site workers generally are associated with handling of radioactive materials used in the on-site facilities and with inhalation of radionuclides released from processes conducted on-site. Members of the off-site general public are exposed to radionuclides discharged from on-site facilities through airborne and/or waterborne emissions.

The total radiation dose to the maximally exposed individual (MEI) of the general public is estimated to be 1.7 mrem/yr, which is much lower than the maximum radiation dose limit set for the general public of 100 mrem/yr from operation of a DOE facility (DOE Order 5400.5). The average external radiation dose for cylinder yard workers has ranged from 16 to 56 mrem/yr (Hodges 1996) in the past few years and has been well below the maximum dose limit of 5,000 mrem/yr set for radiation workers (10 CFR Part 835). All of these exposures are a very small fraction of the 360 mrem/yr dose received by the general public and workers from natural background and medical sources (Table 2.3).

2.7.2 Chemical Environment

Estimated hazard quotients for members of the general public under existing environmental conditions near the Paducah site are presented in Table 2.4. The hazard quotient represents a comparison of estimated human intake levels with intake levels below which adverse effects are very unlikely to occur (see Chapter 4 of the PEIS for further details). The estimated hazard quotients indicate that exposures to depleted UF₆-related contaminants in environmental media near the Paducah site are generally a small fraction of those that might be associated with adverse health effects. An exception is groundwater, where hazard quotients for several substances could exceed the threshold of 1. However, because this groundwater is not a drinking water source, there is no exposure. The residents near the PGDP whose wells have been contaminated have been provided with alternate water sources.

The Occupational Safety and Health Administration (OSHA) has proposed permissible exposure limits (PELs) for uranium compounds and hydrogen fluoride (HF) in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998), as follows: 0.05 mg/m³ for soluble uranium compounds; 2.5 mg/m³ for HF. Paducah worker exposures are kept below these limits.

2.8 SOCIOECONOMICS

The socioeconomic environment of the Paducah site was assessed in terms of regional economic activity, population and housing, and local public finances. The region of influence (ROI) consists of Ballard, Carlisle, Graves, Marshall, and McCracken Counties in Kentucky, and Massac County in Illinois; 93.1% of employees at the site currently reside in those counties, with 59.1% residing in McCracken County (DOE 1997). Allison and Folga (1997) provide a listing of the counties, cities, and school districts within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

TABLE 2.3 Estimated Radiation Doses to Members of the General Public and to Cylinder Yard Workers at the Paducah Gaseous Diffusion Plant

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI) ^a	Routine site operations	
	Airborne radionuclides	0.0023 ^b
	Waterborne radionuclides	0.67 ^c
	Direct gamma radiation	1 ^d
	Ingestion of drinking water	0 ^e
	Ingestion of wildlife	0.0023 ^f
Cylinder yard worker	External radiation	16 – 56 ^g
Member of public or worker	Natural background radiation and medical sources	360 ^h
DOE worker limit		2,000 ⁱ

^a The maximally exposed individual (MEI) was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

^b Radiation doses from airborne releases were calculated by using an air dispersion model and considered exposure from external radiation, inhalation, and ingestion of foodstuffs. The MEI is located approximately 1,170 m (3,836 ft) north-northeast of the plant site (LMES 1997c).

^c Radiation doses could result from incidental ingestion of contaminated sediment and inhalation of contaminated particles from fishing, hunting, and other recreational activities in Little Bayou Creek (LMES 1997c).

^d Radiation doses could result from hunting activities on the banks of Little Bayou Creek (LMES 1997c).

^e According to the results of a 1990 survey, there was no reported use of surface water. Also, contaminated well water is not used because all residents in that area receive city water (LMES 1996).

^f Radiation doses could result from ingestion of the edible portion of two average-weight deer containing the maximum detected concentrations of radionuclides (LMES 1997c).

^g Range of annual average doses from years 1990 through 1995 (Hodges 1996).

^h Average dose to a member of the U.S. population as estimated in Report No. 93 of the National Council on Radiation Protection and Measurements (NCRP 1987).

ⁱ DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

TABLE 2.4 Estimated Hazard Quotients for Members of the General Public near the Paducah Site under Existing Environmental Conditions^a

Environmental Medium	Parameter	Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level ^b (mg/kg-d)	Hazard Quotient ^c
Air ^{d,e}	Uranium	0.0078 : g/m ³	2.2×10^{-6}	0.0003	0.0074
	HF	0.096 : g/m ³	2.7×10^{-5}	0.02	0.0014
Soil ^f	Uranium	5.8 : g/g	7.7×10^{-5}	0.003	0.026
Surface water ^e	Uranium	16 : g/L	8.7×10^{-6}	0.003	0.003
	Fluoride	< 224 : g/L	1.2×10^{-4}	0.06	0.002
Sediments ^e	Uranium	360 : g/g	6.2×10^{-6}	0.003	0.033
	Aroclor 1254	1.4 : g/g	3.8×10^{-7}	0.00002	0.019
	Aroclor 1254 ^g	1.4 : g/g	5.5×10^{-8}	2.0 (slope factor)	1.1×10^{-7} (cancer risk)
Groundwater ^h	Uranium	20 : g/L	5.7×10^{-4}	0.003	~ 0.19
	Fluoride	4,000 : g/L	1.1×10^{-1}	0.06	~ 1.9

^a The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

^b The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C of the PEIS. For carcinogens, the slope factor is also given; slope factors in units of (mg/kg-d)⁻¹ are multiplied by lifetime average intake to estimate excess cancer risk.

^c The hazard quotient is the ratio of the intake of the human receptor to the reference level. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely. For carcinogens, the cancer risk (intake \times slope factor) is also given. Increased cancer risks between 10^{-6} and 10^{-4} are considered tolerable at hazardous waste sites; risks less than 10^{-6} are considered negligible.

^d Gross alpha was used as a surrogate measure of uranium concentration.

^e Exposure concentrations are the maximum annual averages for all monitoring locations (MMES 1994a; LMES 1996, 1997a,c).

^f Maximum uranium concentration from 10 plant boundary and off-site soil monitoring locations (LMES 1996).

^g Parameters analyzed for carcinogenic effects; all other parameters were analyzed for noncarcinogenic effects.

^h Data are for monitoring and residential wells located on or near DOE property at the Paducah site (the residential wells are not currently used for drinking water). Several additional substances exceeded reference levels between 1993 and 1996 (Section 2.5.2); listed here are only substances of particular interest for this PEIS. Well-specific concentrations were not available; the exposure concentrations given are actually drinking water standards or guidelines. Hazard indices based on well-specific concentrations could exceed those presented.

2.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 72,300 to 78,900, an increase of 9.1%. Within the ROI, the largest percent employment increase occurred in McCracken County (13.8%), which had 51% of total ROI employment in 1995. The U.S. Bureau of Economic Analysis (BEA) projects a 1.9% increase in employment in the ROI over the period 1995 to 2020 (1,500 jobs), with the largest increase expected in McCracken County (3.5%, 1,400 jobs) (BEA 1996). Unemployment in the ROI in 1996 was 5.4% (Allison 1996). Employment at the Paducah site in 1995 was 1,700 (DOE 1997), amounting to approximately 2.2% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from \$1.6 billion to \$1.8 billion, an increase of 13%. The largest percent increase occurred in McCracken County (20%), which had 46% of total ROI personal income in 1995. The BEA projects a 31.9% increase in ROI personal income from 1995 to 2020 (\$0.6 billion), with the largest increase in McCracken County (33%, \$0.3 billion) (BEA 1996).

2.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 150,271 to 153,000, an increase of 1.8%. The 1995 ROI population was concentrated in McCracken County (41.7%). The BEA projects the ROI population as a whole to increase by 9,600 (6.3%) from 1995 to 2020, with the largest increase in McCracken County (7.7%, 4,900 people) (BEA 1996).

2.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased by 9.6%, from 61,000 to 66,900. McCracken County had 41% of the total housing units. Based on BEA (1996) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the total number of vacant owner-occupied units in the ROI is expected to increase from 4,460 to 4,880 and the total number of vacant rental units from 1,520 to 1,620.

2.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 2.5. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

TABLE 2.5 Summary of Financial Characteristics for the Paducah Site County, City, and School District Regions of Influence

Category	Finances ^a (\$ million)		Category	Finances ^a (\$ million)	
	ROI Counties	ROI Cities		ROI School Districts	
Revenues			Revenues		
Local sources	8.8	6.5	Local sources	23.8	
Fines, fees, permits, etc.	1.3	14.5	State sources	67.2	
Intergovernmental	1.3	6.1	Federal sources	4.1	
Other	0.8	2.6	Other	16.5	
Total	12.3	29.7	Total	111.6	
Expenditures			Expenditures		
General government	6.3	4.7	Administration	2.2	
Safety, health, community services	6.0	16.1	Instruction	67.1	
Debt service	0.0	0.1	Services	8.5	
Other financing sources	1.4	-5.6	Physical plant	9.8	
Total	14.0	15.3	Other	24.4	
			Total	112.1	
Revenues less Expenditures	-1.7	14.4	Revenues less Expenditures	-0.4	

^a Data for fiscal year ending June 30, 1995.

Sources: see Allison and Folga (1997).

2.9 WASTE MANAGEMENT

The affected environment with respect to waste management is considered to be wastewater and solid waste generated at the Paducah site. Disposal of this waste is currently managed by USEC, including any waste generated from ongoing management of the DOE-generated depleted UF₆ cylinders currently in storage. The cylinder storage yards at Paducah currently generate only a very small amount of waste compared with the volume of waste generated from ongoing plant operations. Cylinder yard waste consists of small amounts of metal, scrapings from cylinder maintenance operations, potentially contaminated soil, and miscellaneous items.

The Paducah site generates wastewater, solid low-level radioactive waste (LLW), solid and liquid low-level mixed waste (LLMW), nonradioactive hazardous waste, and nonradioactive nonhazardous solid waste. The site has an active program to minimize the generation of solid LLW, hazardous waste, and LLMW. Waste minimization efforts for radioactive waste include prevention of packaging material from entering radiological areas and replacement of wood pallets used in radiological areas. Hazardous waste and LLMW minimization actions include use of less chlorinated

solvents, recycling of paint wastes, and compaction of PCB wastes. Solid waste minimization actions include recycling of paper and cardboard and off-site recycling of fluorescent bulbs and used batteries.

The Paducah site and nationwide waste loads assumed for the analysis of impacts of projected activities in this report are given in Table 2.6. Details on the waste management impact assessment methods are provided in Appendix C of the PEIS.

2.9.1 Wastewater

Wastewater at the Paducah site consists of nonradioactive sanitary and process-related wastewater streams, cooling water blowdown, and radioactive process-related liquid effluents. Wastewater is processed at on-site treatment facilities and is discharged to Big Bayou Creek or Little Bayou Creek through eight outfalls identified under the site KPDES permit #KY0004049. In 1993, the wastewater treatment system processed approximately 0.4 million gal/d (1.5 million L/d) of

TABLE 2.6 Projected Site and National DOE Waste Treatment Volumes

Waste Category	Waste Treatment Volume ^a (m ³ /yr)	
	Paducah	Nationwide
Low-level waste ^b	2,200	68,000 ^c
Low-level mixed waste ^d	100	19,000 ^c
Hazardous waste ^e	76	-
Nonhazardous waste ^e		
Solids	2,100	-
Wastewater	-	-
Sanitary waste	560,000	-

^a A hyphen (-) indicates no data reported.

^b Source: DOE (1995b).

^c Estimated operational waste for 1995 for all DOE sources combined (DOE 1997).

^d Source: DOE (1995c).

^e Source: DOE (1996).

wastewater. The total capacity of the site wastewater control facilities is approximately 1.75 million gal/d (6.6 million L/d). About 30% of the capacity of wastewater treatment facilities is currently used.

In 1992, the wastewater discharge at the Paducah site was in compliance with KPDES permit requirements 99.5% of the time. A few exceedances occurred for total residual chlorine, trichloroethylene, pH, and total suspended solids (MMES 1994a). In 1994, the PCB effluent limits were exceeded 18 times in site wastewater discharges. These exceedances were addressed through existing site agreements with the state (LMES 1996).

2.9.2 Solid Nonhazardous, Nonradioactive Waste

Solid waste — including sanitary refuse, cafeteria waste, industrial waste, and construction and demolition waste — is collected and disposed of at the on-site landfill, which consists of three cells. The first cell is closed and capped, the second is near capacity, and the third cell awaits final authorization from the Kentucky Division of Waste Management. The total capacity of the landfill is 26,000 yd³ (20,000 m³). The site solid waste generation rate for 1993 was 2,740 yd³/yr (2,100 m³/yr) (DOE 1996).

2.9.3 Nonradioactive Hazardous and Toxic Waste

Nonradioactive waste that is considered hazardous waste according to RCRA or contains PCBs as defined under the *Toxic Substances Control Act* (TSCA) requires special handling, storage, and disposal. The Paducah site generates hazardous waste — including spent solvents and heavy-metal-contaminated waste — and PCB-contaminated toxic waste. The site has a Kentucky Division of Waste Management RCRA Part B permit (#KY8890008982), which expires in 2001. The permit authorizes the Paducah site to treat and store hazardous waste in 10 treatment units, 16 tanks, and 4 container storage areas at the site. There are several additional 90-day storage areas for temporary storage of hazardous waste.

Approximately 99 yd³ (76 m³), or 209 tons (190 metric tons), of solid hazardous waste was generated in 1992. Certain hazardous/toxic wastes are sent to permitted off-site contractors for final treatment and/or disposal. Much of the hazardous/toxic waste load consists of PCB-contaminated waste. More than 370 yd³ (280 m³) of PCBs is used in electrical equipment at the Paducah site (MMES 1994a). Some liquid hazardous and/or mixed waste streams are shipped to the K-25 site for incineration in a TSCA incinerator, which has a capacity of 1,800 yd³/yr (1,400 m³/yr).

2.9.4 Low-Level Waste

LLW generated at the Paducah site is stored on-site pending shipment to a commercial facility in Tennessee for volume reduction. Solid LLW generated at the Paducah site includes refuse, sludge, and debris contaminated with radionuclides, primarily uranium and technetium. The site generated 2,450 yd³ (1,870 m³) of solid LLW in 1991, 650 yd³ (500 m³) in 1992, and approximately 2,880 yd³ (2,200 m³) in 1993. As of 1995, the site had 4,380 yd³ (3,350 m³) of LLW in storage (DOE 1996). Site wastewater treatment facilities can process up to 1,480 yd³ (1,140 m³) per year of aqueous LLW.

2.9.5 Low-Level Mixed Waste

LLW that contains PCBs or RCRA hazardous components is considered to be LLMW. As of 1995, 243 yd³ (186 m³) of LLMW was in storage at the Paducah site. Of this total, 63 yd³ (48 m³) represents waste subject to land disposal restrictions. Solid LLMW generation in 1992 was 1,080 yd³ (824 m³); the generation rate for 1993 was about 130 yd³ (100 m³). In 1992, approximately 560,000 lb (256,000 kg) of organic liquid was sent to the TSCA incinerator on the K-25 site. On-site capacity for storing LLMW containers at the Paducah site is 3,600 yd³ (2,800 m³). The site can treat up to 204 ft³/yr (156 m³/yr) of aqueous LLMW (DOE 1996).

2.10 CULTURAL RESOURCES

Thirty-two cultural resource sites are currently recorded within and immediately surrounding the PGDP. Twenty-two were recorded during surveys conducted in the 1970s and early 1980s, and 10 more were recently recorded during a cultural resources study consisting of a 20% stratified random sample survey for prehistoric and historic archaeological sites. Results of a sensitivity analysis, also conducted as part of the study, indicate that much of the area surrounding the fenced complex has a low or very low index of sensitivity, meaning there is a low probability of finding prehistoric sites near the developed area. However, scattered areas of high sensitivity are located along Little Bayou Creek and Big Bayou Creek; at least three prehistoric sites and one historic site are potentially eligible for the *National Register of Historic Places* (U.S. Department of the Army 1994a,b).

As of 1997, an inventory of historic buildings had been planned, but not conducted at the Paducah site. It is likely that buildings related to uranium enrichment and the gaseous diffusion process that supported atomic weapon manufacture or to activities at the Kentucky Ordnance Works could be eligible for the *National Register*. No cemeteries are located on the Paducah site.

No religious or sacred sites, burial sites, or resources significant to Native Americans have been identified at the Paducah site to date.

2.11 MINORITY AND LOW-INCOME POPULATIONS

Demographic information obtained from the U.S. Bureau of the Census was used to profile the population residing within a 50-mile (80-km) radius of the Paducah site. A 50-mile (80-km) radius was selected because it would capture virtually all of the human health risks and environmental impacts that could potentially occur. A geographic information system based on 1990 Census Bureau *Tiger Line Files* and Summary Tape Files 1 and 3A was used to generate a map illustrating minority and low-income populations residing within the 50-mile (80-km) zone of impact surrounding the site (U.S. Bureau of the Census 1992a,b,c).

The unit of analysis was the census tract. For those census tracts only partially located inside a 50-mile (80-km) radius of the site, an even population distribution was assumed, and the population was calculated as a proportion of the tract area physically located within the 50-mile (80-km) radius (i.e., if 50% of the census area was inside the 50-mile (80-km) radius, then 50% of its population was counted). The map, which is presented in Figure 2.4, depicts the distribution of minority and low-income census tracts within a 50-mile (80-km) radius of the Paducah site. Information regarding the proportion of the total population residing within 50 miles (80 km) of the site that is minority or low-income accompanies the figure.

The proportion thresholds for determining the low-income and/or minority status of a census tract were based on the proportion of low-income and minority populations residing within the state of Kentucky. If the 50-mile (80-km) radius around the site included a portion of another state or states, a weighted average based on all the affected state low-income and minority population proportions was assigned. Other reference threshold proportions were considered (i.e., national, multistate regional), but state population proportions were chosen because they tend to present a more accurate portrayal of the affected population. The population residing within a 50-mile (80-km) radius of the Paducah site was found to consist of 9.2% minorities and 19.0% persons with low income.

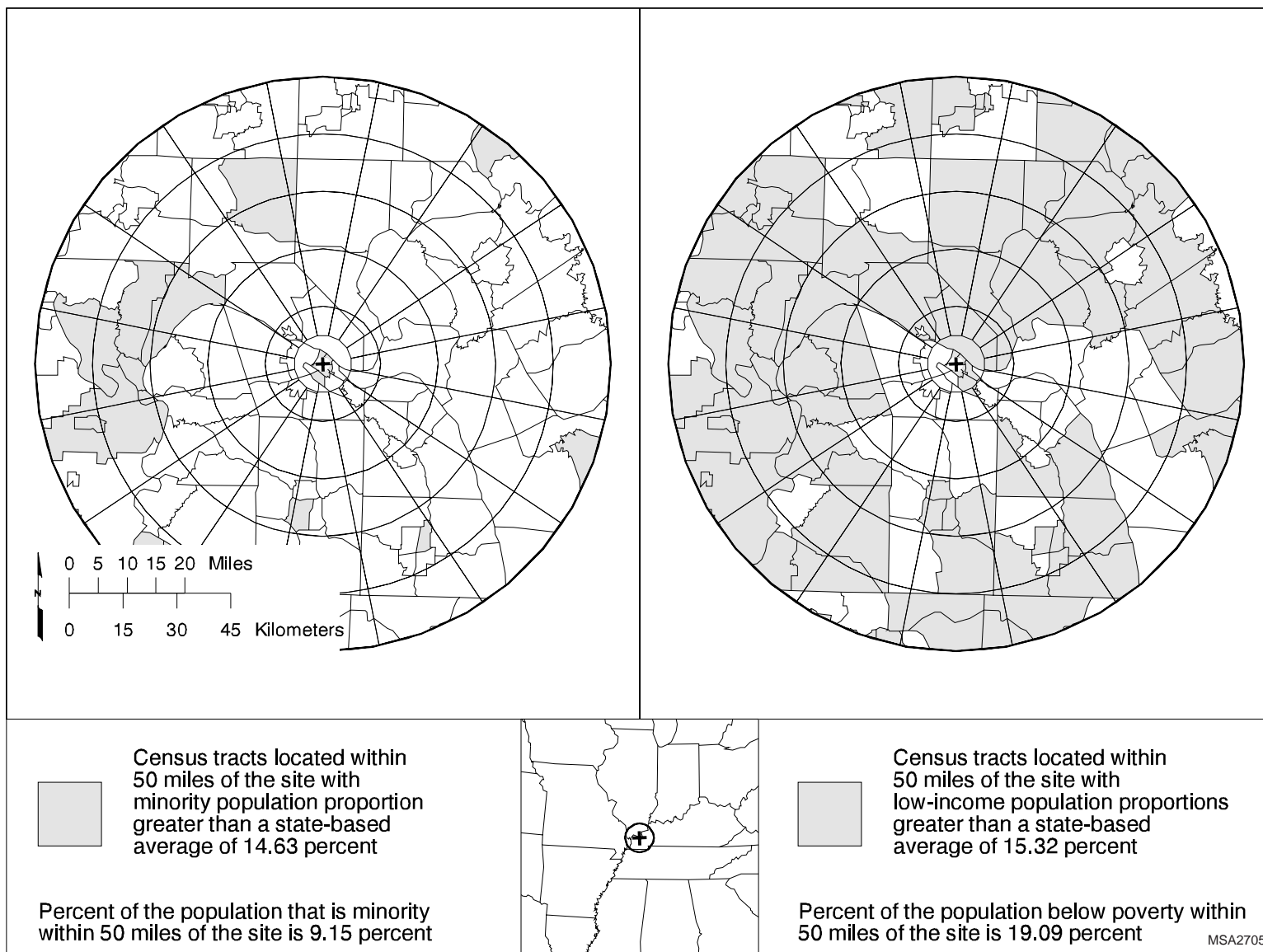


FIGURE 2.4 Distribution of Minority and Low-Income Census Tracts within a 50-Mile Radius of the Paducah Site

3 ENVIRONMENTAL IMPACTS OF CONTINUED CYLINDER STORAGE AT THE PADUCAH SITE

Continued cylinder storage at the Paducah site would be required for some period of time for all alternative management strategies. It was assumed that the entire depleted UF₆ cylinder inventory would continue to be stored at the Paducah site through 2008 for all alternatives. Under the no action alternative, the entire cylinder inventory would continue to be stored at the site indefinitely. For purposes of analysis and comparison with action alternatives, the assessment period considered was through the year 2039. Under the action alternatives, the number of cylinders stored at the site would decrease as the cylinders were transported to another location for conversion or long-term storage. This decrease was assumed to occur from 2009 through 2028.¹ The assessment of impacts from continued cylinder storage considers all anticipated activities required to safely manage the cylinder inventory from 1999 through 2039 for the no action alternative and from 1999 through 2028 for the action alternatives. Potential long-term impacts from cylinder breaches potentially occurring at the Paducah site through the year 2039 (no action alternative) or through 2028 (action alternatives) were estimated by calculating the maximum groundwater contamination levels possible in the future from those breaches.

Continued Storage of Cylinders

The continued storage of depleted UF₆ cylinders at the Paducah site would be required for some period of time for all alternative management strategies. Continued storage would involve maintenance of the cylinders — including inspections, painting, and cylinder yard upgrades — as well as valve replacement and cylinder repair, as needed. The impacts of continued storage at the Paducah site were assessed separately for the following:

No Action Alternative: Potential impacts were assessed for continued storage of the cylinder inventory at the Paducah site through the year 2039, including potential long-term impacts to groundwater and human health and safety.

Action Alternatives: Potential impacts were assessed for continued storage at the Paducah site based on the assumption that the number of cylinders at the site would begin to decrease in the year 2009 and that all of the cylinders would be removed by the end of the year 2028 (corresponding to the period during which conversion or long-term storage would be implemented). Potential long-term impacts were also assessed.

The cylinder surveillance and maintenance activities that are to be undertaken from now through September 30, 2002, are described in detail in the *UF₆ Cylinder Project Management Plan* (LMES 1997d). However, because the assessment period extends through the year 2039, a set of

¹ These estimates were meant to provide a consistent analytical time frame for the evaluation of all the PEIS alternatives and do not represent a definitive schedule. When USEC-generated cylinders are considered, the time frame for action alternatives extends to 2034 (see Sections 3.1 and 3.5).

assumptions was needed to define the activities for estimating the impacts of continued storage through 2039. The assumptions used are documented in a memo by J.W. Parks, Assistant Manager for Enrichment Facilities, DOE Oak Ridge Operations Office (Parks 1997). In developing these assumptions, it was recognized that the activities actually undertaken might differ from those described in the cylinder project management plan. Therefore, assumptions were chosen such that anticipated impacts of continued cylinder storage made in the PEIS would result in conservative estimates (that is, the assumptions used would overestimate impacts rather than underestimate them).

Impacts associated with the following activities were analyzed: (1) storage yard reconstruction and cylinder relocations; (2) routine and ultrasonic testing inspections of cylinders and valve monitoring and maintenance; (3) cylinder painting; and (4) repair and removal of the contents of any cylinders that might be breached during the storage period. Although actual activities occurring at the site during the time period considered might vary from those described in the cylinder project management plan, the estimated impacts of continued storage activities assessed in this report are likely to encompass and bound the impacts. The assumptions for each activity are discussed further in the following paragraphs.

The inventory of depleted UF₆ cylinders generated by DOE before 1993 that is stored in 13 yards at the Paducah site is 28,351 cylinders (60% of the total inventory). An intensive effort is ongoing to improve yard storage conditions. This effort includes (1) relocation of some cylinders, which are currently either in contact with the ground or are too close to one another to allow for adequate inspections, and (2) construction of new storage yards or reconstruction of existing storage yards to provide a stabilized concrete base and monitored drainage for the cylinder storage areas. The impacts planned from relocation and construction activities that will not be complete by 1999 are included for consideration as part of continued cylinder storage; these activities include reconstruction of four yards and relocation of about 19,000 cylinders at the Paducah site.

The stored cylinders are regularly inspected for evidence of damage or accelerated corrosion; about 75% are inspected every 4 years, and 25% are inspected annually. Annual inspections are required for those cylinders that have been stored previously in substandard conditions and/or those that show areas of heavy pitting or corrosion. In addition to these routine inspections, ultrasonic inspections are currently conducted on some of the relocated cylinders. The ultrasonic testing is a nondestructive method to measure the wall thickness of cylinders. Valve monitoring and maintenance are also conducted for cylinders that exhibit discoloration of the valve or surrounding area during routine inspections. Leaking valves are replaced in the field. Impacts from routine inspections, ultrasonic inspections, and valve maintenance are evaluated as components of continued cylinder storage. For assessment of the no action alternative, the frequency of routine inspections and valve monitoring was assumed to remain constant through 2039, and ultrasonic testing was assumed to be conducted annually for 10% of the relocated cylinders. Relocation activities would be completed in about 2003, after which 10% of the cylinders painted each year

were assumed to be inspected by ultrasonic testing. For the action alternatives, the frequency of inspections was assumed to decrease with decreasing cylinder inventory (about a 5% decrease in inspections per year) from 2009 through 2028.

Current plans call for cylinder painting to control cylinder corrosion. On the basis of information from the cylinder painting program (Pawel 1997), the analysis assumed that the paint would protect the cylinders for at least 10 years and that, once painted, the cylinders would not undergo further corrosion during that time. Although repainting might not actually be required every 10 years, the analysis assumed that every cylinder would be repainted every 10 years (except for the period 2019 through 2028 for the action alternatives, during which time no painting was assumed because of decreasing inventory size — i.e., cylinders being removed within 10 years for conversion or long-term storage elsewhere would not be repainted). The painting activity includes cylinder surface preparation (e.g., scraping and removal of rust deposits). Because some radioactive contaminants may exist on the surface of cylinders and because the metal content of the paints used previously are unknown, for purposes of analysis, the waste generated during surface preparation was considered to be low-level mixed waste (i.e., hazardous waste plus low-level radioactive waste). Cylinder painting activities would be the primary source of potential radiological exposures for involved workers under the continued cylinder storage option.

One breached cylinder has been identified at the Paducah site. A breached cylinder is a cylinder that has a hole of any size at some location on the wall. Investigation of the breach concluded that it was caused by damage during handling. The hole size was approximately $1/16 \times 2$ in. (0.16×5.1 cm). The contents of the cylinder were transferred to another cylinder. When cylinders are breached, moist air reacts with the exposed UF_6 and iron, resulting in the formation of a dense plug of uranium tetrafluoride (UF_4) and iron fluoride hydrates that prevents rapid loss of material from the cylinders. Further details on cylinder corrosion and releases due to breaches are given in Appendix B of the PEIS.

Considering the improved storage conditions in the yards, intensive inspection schedule, and the planned cylinder painting, the impact analysis for the no action alternative was based on the assumption that breaches resulting from corrosion would cease. Therefore, the primary potential cause of breaches considered for continued storage was mechanical damage occurring during cylinder handling (e.g., for painting or relocations). Although stringent inspection procedures are now in place to immediately identify and repair any cylinder breaches that might occur during handling, for purposes of analysis it was nonetheless assumed that breaches caused by mechanical damage would continue to occur at the same rate as in the past and that the breaches would go unidentified for a long enough time for releases to occur (see Appendix B of the PEIS). On the basis of these assumptions, the total number of breaches assumed to occur from 1999 through 2039 for the no action alternative analyses (base case) was 36 (Table 3.1) for the Paducah site.

TABLE 3.1 Estimated Number of Breaches and Releases from 28,351 DOE-Generated Cylinders at the Paducah Site from 1999 through 2039, Assuming Control of External Corrosion by Painting^a

Year of Breach	Number of Breaches ^b	Number of Active Breaches ^c	HF Emissions ^d (kg/yr)	Year of Breach	Number of Breaches ^b	Number of Active Breaches ^c	HF Emissions ^d (kg/yr)
1999	2	2	4	2020	1	4	8
2000	1	3	6	2021	0	3	6
2001	1	4	8	2022	1	3	6
2002	1	5	10	2023	1	3	6
2003	2	5	10	2024	1	3	6
2004	1	5	10	2025	0	3	6
2005	0	4	8	2026	1	3	6
2006	1	4	8	2027	1	3	6
2007	1	3	6	2028	1	3	6
2008	1	3	6	2029	1	4	8
2009	1	4	8	2030	0	3	6
2010	1	4	8	2031	1	3	6
2011	0	3	6	2032	1	3	6
2012	1	3	6	2033	1	3	6
2013	1	3	6	2034	1	4	8
2014	1	3	6	2035	0	3	6
2015	0	3	6	2036	1	3	6
2016	1	3	6	2037	1	3	6
2017	1	3	6	2038	1	3	6
2018	1	3	6	2039	1	4	8
2019	1	4	8	Total	36		

^a PEIS analyses were conducted for the period 1999 through 2039. Existing models also predicted one possible breach for 1998 due to handling.

^b Estimates based on the assumption that a painting program would be effective in eliminating external corrosion by the year 2009. Breaches prior to 2009 were calculated as the sum of corrosion-initiated breaches for the proportion left unpainted in each year (based on external corrosion statistical model [Lyon 1996, 1997]) plus the handling-initiated breaches. For 2009–2039, only handling-initiated breaches were assumed. The breaches were assumed to go undetected for 4 years; in practice, improved storage conditions and maintenance and inspection procedures should prevent any breaches from occurring or going undetected for long periods.

^c Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

^d Annual HF emissions (kg/yr) = number of active breaches × 0.0055 kg per breached cylinder per day × 365 days per year.

The above breach number was used to estimate potential impacts from repairing breached cylinders and from releases that might occur during continued storage through 2039 under the no action alternative. Potential radiological exposures of involved workers could result from patching breached cylinders and subsequently emptying the cylinder contents into new cylinders. The impacts to groundwater and human health and safety from uranium releases were assessed by estimating the amount of uranium that could be transported from the yards in surface runoff, followed by estimating migration through the soil to the groundwater.

The uncertainty in both the effectiveness of painting in controlling further corrosion and in the future painting schedule was addressed by also conducting a conservative assessment based on the assumption that external corrosion would not be halted by improved storage conditions and painting, resulting in more breaches (see Section 3.3). On the basis of these assumptions, the total number of breaches estimated from 1999 through 2039 was 444 for the Paducah site (Table 3.2). The results of this assessment were used to provide an estimate of the earliest time when continued cylinder storage could begin to raise regulatory concerns under these worst-case conditions.

For the action alternatives, continued storage would occur through 2028, with the inventory decreasing by about 5% per year starting in 2009 until no cylinders would remain at the site in 2028. Because the status of a cylinder painting program is less certain for the action alternatives, the estimated number of breached cylinders for these alternatives was based on the assumption that external corrosion was not controlled by painting (see Section 3.4 for a discussion of potential impacts for the action alternatives).

For all hypothetical cylinder breaches, it was assumed that the breach would go undetected for a period of 4 years, which is the duration between planned inspections for most of the cylinders. In practice, cylinders that show evidence of damage or heavy external corrosion are inspected annually, so it is unlikely that a breach would go undetected for a 4-year period. On the basis of estimates from investigation of cylinder breaches that have occurred to date, 1 lb (0.45 kg) of uranium (in the form of uranyl fluoride [UO₂F₂]) and 4.4 lb (2 kg) of HF were assumed to be released from each breached cylinder annually for a period of 4 years (see Tables 3.1 and 3.2).

3.1 SUMMARY OF CONTINUED CYLINDER STORAGE IMPACTS

This section provides a summary of the potential environmental impacts associated with continued cylinder storage at the Paducah site for the no action alternative and for the action alternatives. Additional discussion and details related to the assessment methodologies and results for each area of impact are provided in Sections 3.2 and 3.4. After the draft PEIS was completed, management responsibility for approximately 8,600 additional cylinders of depleted UF₆ at the Paducah site was transferred from USEC to DOE. To account for uncertainties associated with the number of cylinders that would be transferred from USEC to DOE in the future and to provide a

TABLE 3.2 Estimated Number of Breaches and Releases from DOE-Generated Cylinders at the Paducah Site from 1999 through 2039, Assuming Historical Corrosion Rates

Year of Breach	Breaches and Releases at G-Yard (5,733 Cylinders)			Breaches and Releases at All Other Yards (22,618 Cylinders)		
	Number of Breaches ^a	Number of Active Breaches ^b	HF Emissions ^c (kg/yr)	Number of Breaches ^a	Number of Active Breaches ^b	HF Emissions ^c (kg/yr)
1999	1	1	2	0	0	0
2000	0	1	2	0	0	0
2001	1	2	4	0	0	0
2002	0	2	4	0	0	0
2003	1	2	4	1	1	2
2004	1	3	6	0	1	2
2005	1	3	6	0	1	2
2006	1	4	8	1	2	4
2007	2	5	10	1	2	4
2008	2	6	12	1	3	6
2009	2	7	14	1	4	8
2010	2	8	16	1	4	8
2011	3	9	18	1	4	8
2012	3	10	20	1	4	8
2013	3	11	22	1	4	8
2014	4	13	26	1	4	8
2015	4	14	28	1	4	8
2016	5	16	32	1	4	8
2017	5	18	36	2	5	10
2018	5	19	38	1	5	10
2019	6	21	42	2	6	12
2020	7	23	46	1	6	12
2021	7	25	50	2	6	12
2022	8	28	56	2	7	14
2023	8	30	60	3	8	16
2024	9	32	64	2	9	18
2025	10	35	70	3	10	20
2026	10	37	74	2	10	20
2027	11	40	80	3	10	20
2028	13	44	88	4	12	24
2029	13	47	94	3	12	24
2030	15	52	104	4	14	28
2031	17	58	116	4	15	30
2032	17	62	124	5	16	32
2033	19	68	137	4	17	34
2034	20	73	147	5	18	36

TABLE 3.2 (Cont.)

Year of Breach	Breaches and Releases at G-Yard (5,733 Cylinders)			Breaches and Releases at All Other Yards (22,618 Cylinders)		
	Number of Breaches ^a	Number of Active Breaches ^b	HF Emissions ^c (kg/yr)	Number of Breaches ^a	Number of Active Breaches ^b	HF Emissions ^c (kg/yr)
2035	21	77	155	5	19	38
2036	22	82	165	6	20	40
2037	23	86	173	6	22	44
2038	24	90	181	6	23	46
2039	25	94	189	6	24	48
Total	351			93		
Total at site			444			

^a These estimates are conservative estimates used for assessing potential impacts based on an external corrosion statistical model (Lyon 1996, 1997). The estimates were based on the assumption that historical corrosion rates would continue through 2039 (i.e., that corrosion would not have been eliminated by painting and maintenance). In practice, painting of cylinders, improved storage conditions, and maintenance and inspection procedures should prevent any breaches from occurring or from going undetected for long periods.

^b Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

^c Annual HF emissions (kg/yr) = number of active breaches \times 0.0055 kg per breached cylinder per day \times 365 days per year.

bounding analysis of environmental impacts, the final PEIS evaluated the environmental impacts of managing an additional 12,000 cylinders at the Paducah site. The impacts associated with continued storage of the total cylinder inventory (including USEC-generated cylinders) under both the no action alternative and the action alternatives are summarized here in Section 3.5. A summary of the estimated environmental impacts associated with continued storage of the DOE-generated cylinders only and the total cylinder inventory (DOE-generated plus USEC-generated) is presented in Table 3.3 and the following text:

- Through the year 2039 for the no action alternative and the year 2034 for the action alternatives, all health and safety impacts to workers and the general public in the vicinity of the Paducah site as a result of cylinder storage and maintenance activities are estimated to be well within the applicable health and safety standards.
- All postulated accidents, including the highest consequence accidents, were estimated to result in zero latent cancer fatalities (LCFs) due to radiological causes among both workers and members of the general public. Some

TABLE 3.3 Summary of Continued Cylinder Storage Impacts at the Paducah Site^a

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
<i>Human Health – Normal Operations: Radiological</i>			
Involved Workers:	Involved Workers:	Involved Workers:	Involved Workers:
Total collective dose: 900 person-rem [1,300 person-rem]	No impacts	Total collective dose: 450 person-rem [640 person-rem]	No impacts
Total number of LCFs: 0.4 LCF [0.5 LCF]		Total number of LCFs: 0.2 LCF [0.3 LCF]	
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
Maximum annual dose to MEI: 0.11 mrem/yr [0.15 mrem/yr]	No impacts	Maximum annual dose to MEI : 0.26 mrem/yr [0.37 mrem/yr]	No impacts
Maximum annual cancer risk to MEI: 4×10^{-8} per year [6×10^{-8} per year]		Maximum annual cancer risk to MEI: 1×10^{-7} per year	
Total collective dose: 0.09 person-rem [0.13 person-rem]		Total collective dose: 0.36 person-rem [0.51 person-rem]	
Total number of LCFs: 4×10^{-5} LCF [5×10^{-5} LCF]		Total number of LCFs: 0.0001 LCF [0.0002 LCF]	
General Public:	General Public:	General Public:	General Public:
Maximum annual dose to MEI: 0.03 mrem/yr [0.04 mrem/yr]	Maximum annual dose to MEI: 0.051 – 0.41 mrem/yr	Maximum annual dose to MEI: 0.10 mrem/yr [0.14 mrem/yr]	Maximum annual dose to MEI: 0.31 – 1.3 mrem/yr
Maximum annual cancer risk to MEI: 1×10^{-8} per year [2×10^{-8} per year]	Maximum annual cancer risk to MEI: 3×10^{-8} – 2×10^{-7} per year	Maximum annual cancer risk to MEI: 3×10^{-8} [4×10^{-8} per year]	Maximum annual cancer risk to MEI: 6×10^{-8} – 7×10^{-7} per year
Total collective dose to population within 50 miles: 0.22 person-rem [0.31 person-rem]	Total collective dose to population within 50 miles: not determined	Total collective dose to population within 50 miles: 0.51 person-rem [0.72 person-rem]	Total collective dose to population within 50 miles: not determined
Total number of LCFs in population within 50 miles: 1×10^{-4} LCF [2×10^{-4} LCF]	Total number of LCFs in population within 50 miles: not determined	Total number of LCFs in population within 50 miles: 0.0002 LCF [0.0004 LCF]	Total number of LCFs in population within 50 miles: not determined

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
<i>Human Health – Normal Operations: Chemical</i>			
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts	General Public: No impacts	General Public: No impacts
<i>Human Health – Accidents: Radiological</i>			
Bounding accident: vehicle-induced fire, 3 full 48G cylinders; ^b bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	No accidents	Bounding accident: vehicle-induced fire, 3 full 48G cylinders; ^b bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	No accidents
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 15 person-rem Number of LCFs: 6×10^{-3}		Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 15 person-rem Number of LCFs: 6×10^{-3}	
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 28 person-rem Number of LCFs in population within 50 miles: 1×10^{-2}		General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 28 person-rem Number of LCFs in population within 50 miles: 1×10^{-2}	

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
Human Health – Accidents: Chemical			
<p>Bounding accident: vehicle-induced fire, 3 full 48G cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects);^b bounding accident frequency: 1 in 10,000 to 1 in 1 million years (vehicle-induced fire); 1 in 100 to 1 in 10,000 (cylinder spill)</p> <p>Noninvolved Workers: Bounding accident consequences (per occurrence):</p> <p>Number of persons with potential for adverse effects: 910 persons</p> <p>Number of persons with potential for irreversible adverse effects: 300 persons</p> <p>General Public: Bounding accident consequences (per occurrence):</p> <p>Number of persons with potential for adverse effects: 1,900 persons</p> <p>Number of persons with potential for irreversible adverse effects: 1 person</p>	<p>No accidents</p>	<p>Bounding accident: vehicle-induced fire, 3 full 48G cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects);^b bounding accident frequency: 1 in 10,000 to 1 in 1 million years (vehicle-induced fire); 1 in 100 to 1 in 10,000 (cylinder spill)</p> <p>Noninvolved Workers: Bounding accident consequences (per occurrence):</p> <p>Number of persons with potential for adverse effects: 910 persons</p> <p>Number of persons with potential for irreversible adverse effects: 300 persons</p> <p>General Public: Bounding accident consequences (per occurrence):</p> <p>Number of persons with potential for adverse effects: 1,900 persons</p> <p>Number of persons with potential for irreversible adverse effects: 1 person</p>	<p>No accidents</p>

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
<i>Human Health — Accidents: Physical Hazards</i>			
Construction and Operations: All Workers: 0.06 fatalities [0.09 fatalities] 71 injuries [100 injuries]	No activities in the long term	Construction and Operations: All Workers: 0.03 fatalities [0.04 fatalities] 41 injuries [60 injuries]	No activities in the long term
<i>Air Quality</i>			
Construction: 24-hour PM ₁₀ potentially as large as 87% of standard. Concentrations of other pollutants all well below standards.	No activities in the long term	Construction: 24-hour PM ₁₀ potentially as large as 87% of standard. Concentrations of other pollutants all well below standards.	No activities in the long term
Operations: HF concentrations well within standard. Criteria pollutant concentrations all well below standards.		Operations: HF concentrations well within standard. Criteria pollutant concentrations all well below standards.	
<i>Water</i>			
Construction: Negligible impacts	Negligible impacts to surface water and groundwater in the long term	Construction: No impacts	Negligible impacts to surface water and groundwater in the long term
Operations: Negligible impacts to surface water and groundwater		Operations: Negligible impacts to surface water; negligible to minor impacts to groundwater	
<i>Soil</i>			
Construction: Minor, but temporary, impacts	No activities in the long term	Construction: No impacts	No activities in the long term
Operations: Negligible impacts		Operations: Negligible impacts	

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
<i>Socioeconomics^c</i>			
Jobs: 20 peak year, construction, 60 per year over 40 years, operations [28 peak year, construction, 85 per year over 40 years, operations]	No activities in the long term	Jobs: 20 peak year, construction, 60 per year over 30 years, operations [28 peak year, construction, 85 per year over 30 years, operations]	No activities in the long term
Income: \$1 million peak year, construction; \$1.8 million per year over 40 years, operations [\$1.4 million peak year, construction; \$2.6 million per year over 40 years, operations].		Income: \$1 million peak year, construction; \$1.8 million per year over 30 years, operations [\$1.4 million peak year, construction; \$2.6 million per year over 30 years, operations].	
Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public housing		Construction and Operations Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public housing	
<i>Ecology</i>			
Construction: Negligible impacts	Negligible impacts to vegetation and wildlife in the long term	Construction: Negligible impacts	Negligible to low impacts to vegetation and wildlife in the long term
Operations: Negligible impacts to vegetation and wildlife		Operations: Negligible impacts to vegetation and wildlife	
<i>Waste Management</i>			
Moderate impacts for the Paducah site waste management operations; negligible impacts to regional or national waste management operations.	No activities in the long term	Moderate impacts for the Paducah site waste management operations; negligible impacts to regional or national waste management operations.	No activities in the long term

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
<i>Resource Requirements</i>			
Negligible impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No activities in the long term	Negligible impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No activities in the long term
<i>Land Use</i>			
Negligible impacts	No activities in the long term	Negligible impacts	No activities in the long term
<i>Cultural Resources</i>			
No impacts	No activities in the long term	No impacts	No activities in the long term
<i>Environmental Justice</i>			
No disproportionate impacts	No activities in the long term	No disproportionate impacts	No activities in the long term

^a Under the no action alternative, continued storage of the cylinder inventory would take place at the Paducah site; under the action alternatives, the number of cylinders stored would decrease by 5% annually from 2009 through 2028. Under all alternatives, potential long-term impacts were evaluated for uranium contamination of soil and groundwater from cylinder breaches through 2028 or 2039. In general, the overall environmental consequences from managing the total cylinder inventory (total of DOE-generated and USEC-generated cylinders) are the same as those from managing the DOE cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE-cylinders only. HF = hydrogen fluoride; LCF = latent cancer fatality; MEI = maximally exposed individual; PM₁₀ = particulate matter with a mean diameter of 10 : m or less; ROI = region of influence.

^b The bounding radiological accident was defined as the accident that would result in the highest dose and risk to the general public MEI; the bounding chemical accident was defined as the accident that would result in the highest population risk (number of people affected).

^c Direct jobs and income are presented for the peak year of construction and for the peak year of operations. See Sections 3.2.5 and 3.4.5 for details on indirect impacts in the Paducah site ROI.

accidents, if they occurred, could result in up to 300 irreversible adverse effects among workers and 1 irreversible adverse effect among the general public due to chemical effects of released materials. However, such accidents have a very low probability and would not be expected to occur through the year 2039 for the no action alternative and the year 2028 for the action alternatives.

- During the assessment period (through 2039 under the no action alternative and 2028 under the action alternatives), all environmental impacts resulting from continued storage activities, including impacts to air resources, water resources, socioeconomics, ecological resources, waste management, land and other resources, cultural resources, and the environmental justice impacts would be negligibly small or well within the applicable standards.
- Long-term impacts from cylinder breaches estimated to occur through 2039 under the no action alternative would be well within the applicable standards assuming that cylinder painting would be effective in controlling corrosion. If no credit were taken for corrosion reduction through painting and continued maintenance, and on the basis of conservative estimates of numbers of breaches and material loss from breached cylinders, it is estimated that the uranium concentrations in the groundwater around the site would exceed the guideline of 20 : g/L used for comparison at some time in the future (around the year 2100 or later). For the action alternatives, all long-term impacts are estimated to remain within the guideline values with or without taking credit for reduced corrosion through painting.

3.2 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE FOR THE NO ACTION ALTERNATIVE

The potential environmental impacts from continued cylinder storage for the no action alternative were evaluated on the basis of activities that were assumed to be required to ensure safe storage of the cylinders (Parks 1997). These activities include routine and ultrasonic inspections of cylinders, valve maintenance, cylinder painting, storage yard reconstruction, and cylinder relocations. Although these activities would minimize the occurrence of cylinder breaches and would aid in the early identification of breached cylinders, the impacts associated with cylinder breaches that might occur during continued storage were assessed. The assessment methodologies are described in Appendix C of the PEIS.

Assumptions for continued storage were generally selected in a manner intended to produce conservative estimates of impact, that is, the assumptions result in an overestimate of the expected

impact. Therefore, although actual activities occurring at the Paducah site during the time period considered might vary, the estimated impacts of continued storage activities assessed are likely to encompass and bound the impacts that could occur. The following general assumptions apply to continued cylinder storage for the no action alternative:

- The current inventory of cylinders at the Paducah site would be maintained through the year 2039.
- The number of breaches assumed to occur under the no action alternative accounts for continued external corrosion prior to the completion of painting of the cylinder inventory. After painting, external corrosion was assumed to cease. Estimated numbers of breaches initiated by mechanical damage caused during cylinder handling are also included. Although current maintenance procedures would most likely lead to immediate identification and repair of any cylinder breaches, some releases of uranium and HF from breached cylinders were assumed for assessment purposes. Impacts were assessed for workers handling the breached cylinders, as well as for noninvolved workers and members of the general public exposed to materials released from breached cylinders.
- To assess potential long-term impacts to groundwater and human health and safety from breached cylinders, potential future groundwater contamination was assessed by assuming that released uranium would be transported from the cylinder storage yards in surface runoff and then migrate through the soil and into groundwater. It was further assumed that public access would be possible for groundwater at the location of the nearest discharge point (i.e., the nearest surface water body in the direction of groundwater flow).
- To address uncertainty in corrosion and cylinder breach assumptions, an assessment was also conducted assuming that external corrosion was not halted by improved maintenance conditions (see Section 3.3 for a discussion of potential impacts).

3.2.1 Human Health — Normal Operations

3.2.1.1 Radiological Impacts

Radiological impacts from normal operations of the Paducah cylinder storage yards were assessed for the involved workers, noninvolved workers, and off-site general public. Radiation

exposures of involved workers would result primarily from external radiation from inspecting and handling the cylinders. Exposures of noninvolved workers would result from airborne releases of UO_2F_2 from breached cylinders. In addition to exposures from airborne releases of UO_2F_2 , the analysis also considered potential exposures of the off-site public to waterborne releases of UO_2F_2 . Such releases would be possible if UO_2F_2 was deposited on the ground surface and washed off by rain to a surface water body or infiltrated with rain to the deeper soil, thereby reaching the groundwater underlying the storage yards. Detailed discussions of the methodologies used in radiological impact analyses are provided in Appendix C of the PEIS and Cheng et al. (1997).

The estimated radiation doses and latent cancer risks are provided in Tables 3.4 and 3.5, respectively. During the storage periods, average radiation exposures of involved workers would be about 740 mrem/yr; exposures of noninvolved workers and members of the general public would be less than 1 mrem/yr. The long-term effects of radiation exposure on the general public resulting from groundwater contamination would be less than 1 mrem/yr. Potential long-term radiological impacts (based on groundwater contamination) are provided in Table 3.6.

The average annual collective worker dose for continued storage activities at the Paducah site would be about 22 person-rem/yr for about 30 workers for the period from 1999 through 2039. The number of workers required for this period was estimated on the basis of the anticipated activities (Parks 1997) and the assumption that the workers would work 5 hours per day in the storage yard. The average individual worker dose would vary from year to year and was estimated to average 740 mrem/yr, which is considerably below the regulatory limit of 5,000 mrem/yr (10 CFR Part 835) and also below the DOE administrative control limit of 2,000 mrem/yr (DOE 1992). Compared with the historical data for worker exposure of 16 to 56 mrem/yr (Hodges 1996), the estimated exposures are greater because of the conservative assumptions made regarding future inspection and maintenance activities (Parks 1997) and the conservatism applied in the analytical methods (see Appendix C, Section C.4.1, of the PEIS).

Radiation doses to noninvolved workers who worked on-site but not within the cylinder storage yards would be less than 0.11 mrem/yr, primarily from inhalation of UO_2F_2 released from breached cylinders. Radiation exposures of members of the off-site general public would result from both airborne and waterborne releases of UO_2F_2 . The radiation dose to the MEI would be less than 0.03 mrem/yr (0.013 mrem/yr from exposure to airborne releases and 0.017 mrem/yr from using contaminated groundwater). The radiation dose from drinking contaminated surface water would be less than 2×10^{-7} mrem/yr. The dose of 0.03 mrem/yr is considerably below the regulatory limit of 10 mrem/yr (40 CFR Part 61) from airborne emissions and 100 mrem/yr (DOE Order 5400.5) from all exposure pathways. The exposure to the off-site public from continued storage activities would be very small compared with the existing exposures (about 3.03 mrem/yr) (LMES 1996) from operations of the entire Paducah site.

TABLE 3.4 Radiological Doses from Continued Cylinder Storage at the Paducah Site under Normal Operations for the No Action Alternative

Annual Dose to Receptor					
Involved Workers ^a		Noninvolved Workers ^b		General Public	
Average Individual Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose ^c (mrem/yr)	Collective Dose ^d (person-rem/yr)	MEI Dose ^e (mrem/yr)	Collective Dose ^f (person-rem/yr)
740	22	0.11	0.0023	0.013 (< 0.017)	0.0053

^a Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. The reported values are averages over the time period 1999–2039. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

^b Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

^c The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest dose. The reported values are the maximums over the time period considered.

^d The reported collective doses are averages over the time periods considered. Population size of the noninvolved workers was assumed to be about 2,000 for the Paducah site.

^e The MEI for the general public was assumed to be located off-site at a point that would yield the largest dose. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

^f Collective dose was estimated for the population within a radius of 50 miles (80 km) around the site. The reported values are averages over the time period considered. The off-site population is 500,000 persons for Paducah. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE 3.5 Latent Cancer Risks from Continued Cylinder Storage at the Paducah Site under Normal Operations for the No Action Alternative

Annual Risk of Latent Cancer Fatality to Receptor					
Involved Worker ^a		Noninvolved Worker ^b		General Public	
Average Individual Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk ^c (risk/yr)	Collective Risk ^d (fatalities/yr)	MEI Risk ^e (risk/yr)	Collective Risk ^f (fatalities/yr)
3×10^{-4}	9×10^{-3}	4×10^{-8}	9×10^{-7}	6×10^{-9} ($< 2 \times 10^{-9}$)	3×10^{-6}

^a Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population. The reported values are averages over the time period 1999–2039.

^b Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

^c The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest risk. The reported values are the maximums over the time period considered.

^d The reported collective risks are averages over the time period considered. Population size of the noninvolved workers was assumed to be about 2,000 for the Paducah site.

^e The MEI for the general public was assumed to be located off-site at a point that would yield the largest risk. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

^f Collective risk was estimated for the population within a radius of 50 miles (80 km) around the site. The reported values are averages over the time period considered. The off-site population is 500,000 persons for Paducah. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

Potential exposures to members of the off-site public after the year 2039 were also assessed for the use of contaminated groundwater resulting from breaches occurring prior to 2039. Depending on the soil properties that determine the time it takes the uranium to reach the groundwater, the maximum individual dose could range from 0.051 to 0.41 mrem/yr, which is considerably lower than the regulatory limit of 100 mrem/yr.

3.2.1.2 Chemical Impacts

Chemical impacts during continued cylinder storage could result primarily from exposure to UO_2F_2 (the product formed when UF_6 is exposed to moist air) and HF released from hypothetical cylinder breaches. Risks from normal operations were quantified on the basis of calculated hazard indexes. Detailed discussions of the exposure assumptions, health effects assumptions, reference doses used for uranium compounds and HF, and calculational methods used in the chemical impact analysis are provided in Appendix C of the PEIS and Cheng et al. (1997).

Hazardous chemical impacts to the MEI were calculated for both noninvolved workers and members of the general public; the results are summarized in Table 3.7. Chemical exposures of noninvolved workers and the off-site general public could result from airborne emissions of UO_2F_2 and HF that could be dispersed from hypothetical cylinder breaches into the atmosphere and to the ground surface. The exposure pathways assessed included inhalation of UO_2F_2 and HF and ingestion of UO_2F_2 in soil. In all cases, the MEI hazard index would be considerably below 1, indicating no potential adverse health effects.

3.2.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents was presented in the SARs for the three storage sites (LMES 1997b,e,f). The potential accidents discussed in the SARs included natural phenomena

TABLE 3.6 Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage at the Paducah Site under the No Action Alternative^{a,b}

Impact to MEI of General Public	
Radiation Dose ^c (mrem/yr)	Latent Cancer Risk ^c (risk/yr)
0.051 – 0.41	$3 \times 10^{-8} - 2 \times 10^{-7}$

^a The long-term impacts correspond to the time after the year 2039.

^b Long-term impacts would be caused by the potential use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. Contamination of groundwater would result from releases from hypothetically breached cylinders and the resulting infiltration of UO_2F_2 to the deeper soils, eventually reaching the groundwater (UO_2F_2 is the product of UF_6 reacting with moisture in air).

^c Radiation doses and latent cancer risks are expressed as ranges, which would result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2039, assuming no mitigation action was taken.

TABLE 3.7 Chemical Impacts to Human Health from Continued Cylinder Storage at the Paducah Site under Normal Operations for the No Action Alternative

Time Period	Impact to Receptor			
	Noninvolved Workers ^a		General Public ^b	
	Hazard Index ^c for MEI	Population Risk ^d (ind. at risk/yr)	Hazard Index ^c for MEI	Population Risk ^d (ind. at risk/yr)
1999–2039	1.0×10^{-3}	–	2.6×10^{-3} (2.1×10^{-3})	–
Long term ^e	NA ^f	–	0.01 – 0.05	–

^a Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. The MEI for the noninvolved worker was assumed to be at the on-site (outside storage yards) location that would yield the largest exposure. Exposures would result from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders; the exposure pathways considered included inhalation and incidental ingestion of soil.

^b The MEI for the general public was assumed to be located off-site at the point that would yield the largest exposure. Results reported are the maximum values over the time period considered and would result from exposure via inhalation; ingestion of soil (resulting from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders); and drinking surface water (consequence of the discharge of contaminated runoff water to a surface water body). Potential impacts during the storage period 1999-2039 (values within parentheses) were also evaluated from the use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

^c The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

^d Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

^e Long-term impacts would result from using contaminated groundwater. Ranges result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2039, assuming no mitigative measures were taken.

^f NA = not applicable; workers were assumed not to ingest groundwater.

events such as earthquakes, tornadoes, and floods, and spills from corroded cylinders under various weather conditions. The accidents selected for analysis for the PEIS and this report were those accident scenarios in the SARs that resulted in the greatest potential consequences for each of the four frequency categories (likely, unlikely, extremely unlikely, and incredible); these accidents are listed in Table 3.8. The accidents do not include natural phenomena events, which were found in the SARs to have less serious consequences than other types of accident scenarios (e.g., a vehicle-induced fire affecting three UF₆ cylinders). In those instances where it was not absolutely clear from the SAR which accident would be the bounding accident in a frequency category, several accidents were included in the analyses, as indicated in Table 3.8. The resulting radiological doses and adverse health impacts from chemical exposures for all the accidents listed in Table 3.8 are presented in Policastro et al. (1997). In the following sections, the results for only the bounding accident in each frequency category are presented. Detailed descriptions of the methodology and assumptions used in these calculations are provided in Appendix C of the PEIS and Policastro et al. (1997).

3.2.2.1 Radiological Impacts

Table 3.9 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table 3.10. The doses and the risks are presented for two different meteorological conditions (D and F stability classes) (see Appendix C of the PEIS). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely (EU) category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.
- The maximum radiological dose to worker and general public MEIs (assuming that an accident occurred) would be 0.077 rem. This dose is less than the 25-rem dose recommended by the U.S. Nuclear Regulatory Commission (NRC 1994) for assessing the adequacy of protection of public health and safety from potential accidents.
- The overall radiological risk to worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table 3.10] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the continued storage accidents.

TABLE 3.8 Accidents Considered for the Continued Storage Option at the Paducah Site

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the dry ground.	UF ₆	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Vehicle-induced fire, 3 full 48Y cylinders	Three full 48Y UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 18,000 2,770 8,010	0 to 24 24 24 to 30 30 to 236	Ground
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	4,240 1,190	0 to 30 30 to 121	Ground
Small plane crash, 2 full 48Y cylinders	A small plane crash affects two full 48Y UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0 6,020 920 2,670	0 to 24 24 24 to 30 30 to 236	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	3,210 2,730	0 to 30 30 to 236	Ground

^a Ground-level releases were assumed to occur outdoors on the concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

TABLE 3.9 Estimated Radiological Doses per Accident Occurrence for Continued Cylinder Storage at the Paducah Site under the No Action Alternative^a

Accident ^a	Frequency Category ^b	Maximum Dose ^c				Minimum Dose ^c			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.4	2.3×10^{-3}	2.6×10^{-1}	3.3×10^{-3}	6.3×10^{-2}	9.8×10^{-5}	3.0×10^{-2}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.5×10^1	1.5×10^{-2}	2.8×10^1	3.7×10^{-3}	1.3	1.9×10^{-3}	1.1

^a The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^b Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^c Maximum and minimum doses reflect differences in assumed meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed. An exception is the vehicle-induced fire involving 3 full 48G cylinders, which would result in a higher population dose for the general public under D stability with 4 m/s wind speed.

TABLE 3.10 Estimated Radiological Health Risks per Accident Occurrence for Continued Cylinder Storage at the Paducah Site under the No Action Alternative^a

Accident ^b	Frequency Category ^c	Maximum Risk ^d (LCFs)				Minimum Risk ^d (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Corroded cylinder, dry conditions	L	3×10^{-5}	6×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	3×10^{-5}	5×10^{-8}	1×10^{-5}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	1×10^{-2}	1×10^{-6}	5×10^{-4}	1×10^{-6}	5×10^{-4}

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times the number of years of operation (41 for the no action alternative). The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum risks reflect differences in assumed meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed. An exception is the vehicle-induced fire involving 3 full 48G cylinders, which would result in a higher population dose for the general public under D stability with 4 m/s wind speed.

3.2.2.2 Chemical Impacts

The accidents discussed in this section are listed in Table 3.8. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables 3.11 and 3.12. The results are presented as (1) number of persons with the potential for adverse effects and (2) number of persons with the potential for irreversible adverse effects. The tables present the results for the accident within each frequency category that would affect the largest number of people (total of workers and off-site population) (Policastro et al. 1997). The impacts presented are based on the assumption that the accidents would occur. The accidents listed in Tables 3.11 and 3.12 are not identical because an accident with the largest impacts for the adverse effects endpoint might not lead to the largest impacts for the irreversible adverse effects endpoint. Detailed descriptions of the methodology and assumptions for assessing chemical impacts are provided in Appendix C of the PEIS. The following conclusions may be drawn from the chemical impact results:

- If the accidents identified in Tables 3.11 and 3.12 did occur, the number of persons in the off-site population with the potential for adverse effects would range from 0 to 1,900 (maximum corresponding to the vehicle-induced fire scenario), and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 1 (maximum corresponding to the corroded cylinder spill with pooling conditions scenario).
- If the accidents identified in Tables 3.11 and 3.12 did occur, the number of noninvolved workers with the potential for adverse effects would range from 0 to 910 (maximum corresponding to the vehicle-induced fire scenario), and the number of noninvolved workers with the potential for irreversible adverse effects would range from 0 to 300 (maximum corresponding to the corroded cylinder spill with pooling scenario).
- Accidents resulting in a vehicle-induced fire involving three full 48G cylinders during very stable (nighttime) meteorological conditions would have a very low probability of occurrence but could affect a large number of people.
- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (41 years, 1999-2039). The results indicate that the maximum risk values would be less than 1 for all accidents, except the following:

- *Potential Adverse Effects:*

Corroded cylinder spill, dry conditions (L, likely), workers

TABLE 3.11 Number of Persons with Potential for Adverse Effects from Accidents under Continued Cylinder Storage at the Paducah Site for the No Action Alternative^a

Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
Corroded cylinder spill, dry conditions	L	Yes	10	No	0	Yes	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	690	Yes	14	Yes	7	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	910	Yes	1,900	Yes	4	Yes	3

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times the number of years of operations (41 for the no action alternative). The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum risks reflect different meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under the meteorological condition of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential adverse effects to an individual.

TABLE 3.12 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under Continued Cylinder Storage at the Paducah Site for the No Action Alternative^a

Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
Corroded cylinder spill, dry conditions	L	Yes	1	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	130	Yes ^f	0	Yes	1	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	300	Yes	1	Yes	1	No	0

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum risks reflect different meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under the meteorological condition of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential irreversible adverse effects to an individual.

^f MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

- *Potential Irreversible Adverse Effects:*

Corroded cylinder spill, dry conditions (L, likely), workers

Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible adverse effects was estimated. All the bounding case accidents shown in Table 3.12 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures would likely be high enough to result in death for 1% or less of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for workers experiencing a range of 0 to 300 irreversible adverse effects, approximately 0 to 3 deaths would be expected. Similarly, of the general public experiencing a range of 0 to 1 irreversible adverse effects, less than 1 death would be expected. These are the maximum potential consequences of the accidents, the upper ends of the ranges assume worst-case weather conditions and that the wind would be blowing in the direction where the highest number of people would be exposed.

3.2.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries for workers (involved and noninvolved) conducting activities associated with continued storage was calculated using industry-specific statistics from the U.S. Bureau of Labor Statistics, as reported by the National Safety Council (1995). Annual fatality and injury rates for manufacturing activities were used for all activities except cylinder yard construction or reconstruction; rates specific to construction were available for these activities. Injury incidence rates used were for injuries involving lost workdays (not including the day of injury).

The activities included as part of the continued storage strategy are routine cylinder inspections, ultrasonic inspections, valve monitoring and maintenance activities, cylinder relocations, cylinder yard construction or reconstruction, cylinder painting, and patching and content transfers for breached cylinders (Parks 1997). These activities were assumed to be continued at currently planned levels through the year 2039, except for yard construction and reconstruction, which were

assumed to be completed by the year 2003. The annual labor requirements and the corresponding fatality and injury risks for these activities were estimated to be as follows: the fatality risk would be less than 1 (0.056), and the injury risk would be about 71 injuries.

3.2.3 Air Quality

The analysis of air quality impacts for continued cylinder storage under the no action alternative was based on three emissions-producing activities: (1) construction of new storage yards; (2) relocation and painting of cylinders; and (3) estimated HF emissions resulting from hypothetical cylinder breaches. The air quality impacts of these three activities at the Paducah site are addressed in this section. Additional details on the assessment of air quality impacts is presented in Tschanz (1997a,b).

The potential impacts of construction were modeled on the basis of assuming area sources located at the yards being reconstructed. The maximum impacts at the Paducah site would occur in 1999 when the L-yard is scheduled for reconstruction. The 1-hour and annual maximum concentrations of criteria pollutants — hydrocarbons (HC), CO, NO_x, SO_x, and PM₁₀ — that would occur during construction of that yard are listed in Table 3.13. The annual PM₁₀ concentration of 16.7 : g/m³ is about 33% of the applicable 50-: g/m³ standard. The 24-hour estimated maximum PM₁₀ concentration of 131 : g/m³ is 87% of the 150-: g/m³ standard. With monitored 24-hour PM₁₀ concentrations in the vicinity of the Paducah site in the range of 50 to 60 : g/m³, the estimated maximum concentration from construction of the yard could raise the total above the standard. The construction fugitive dust emissions used here were based on a general emission factor that considers only the size of the disturbed area and might be an overestimate for the actual use of construction equipment on the site.

Detailed information about the planned construction would be required to more accurately assess the likely actual impacts. However, because the construction site would be adjacent to the facility boundary, it is likely that some measures would be required to reduce the generation of fugitive dust during reconstruction of the yard. Other estimated pollutant concentrations are much smaller fractions of their respective standards, in general being of the order of 1 to 2% of the standard.

Relocating and painting cylinders would involve powered units that produce internal combustion emissions. The paint to be used on the cylinders would be an additional source of VOC emissions (HC is an indicator of VOC sources). Because the relocation and painting of cylinders would generally occur at several locations for each site, emissions from those activities were modeled as point sources at the centers of the sites. The maximum number of annual cylinder relocations that would be required at Paducah during the no action alternative would be 4,200; the

TABLE 3.13 Maximum Concentrations of Criteria Pollutants at Paducah Site Boundaries during Yard Construction^a

Pollutant	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concen- tration (: g/m ³)	Fraction of Standard ^b	Concen- tration (: g/m ³)	Fraction of Standard ^b	Concen- tration (: g/m ³)	Fraction of Standard ^b	Concen- tration (: g/m ³)	Fraction of Standard ^b
CO	220	0.0055	112	0.011	37.3	—	4.76	—
HC ^c	22.5	—	11.5	—	3.84	—	0.489	—
NO _x	85.0	—	43.4	—	14.5	—	1.85	0.02
SO _x	9.02	—	4.59	—	1.53	—	0.196	0.003
PM ₁₀	768	—	391	—	131	0.87	16.7	0.33

^a Values are based on reconstruction of the L-yard.

^b Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

^c HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

TABLE 3.14 Maximum Concentrations of Criteria Pollutants at Paducah Site Boundaries due to Cylinder Relocations^a

Pollutant	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concen- tration (: g/m ³)	Fraction of Standard ^b	Concen- tration (: g/m ³)	Fraction of Standard ^b	Concen- tration (: g/m ³)	Fraction of Standard ^b	Concen- tration (: g/m ³)	Fraction of Standard ^b
CO	13.3	0.0033	1.66	0.00017	0.554	—	0.0244	—
HC ^c	1.07	—	0.134	—	0.0448	—	0.00197	—
NO _x	1.59	—	0.199	—	0.0665	—	0.00292	0.00003
SO _x	3.84	—	0.482	—	0.161	—	0.00706	0.00009
PM ₁₀	0.337	—	0.0423	—	0.0141	0.0009	0.000620	0.00001

^a Cylinder relocations are planned for the Paducah site during the time frame considered (1999–2039).

^b Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

^c HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

maximum number of cylinders painted annually would be 3,000. Table 3.14 gives the estimated maximum concentrations of criteria pollutants at the Paducah site boundaries due to relocations; Table 3.15 gives the estimated maximum concentrations due to painting activities.

Assumptions regarding the number of hypothetical cylinder breaches were used to estimate maximum annual HF emissions (Tschanz 1997b); these estimates are listed in Table 3.16. The estimated 0.08-: g/m^3 maximum 24-hour average HF concentration at the Paducah site boundary is considerably below the Kentucky primary annual standard for HF of 0.5 part per million (ppm, i.e., $400 : \text{g}/\text{m}^3$).

No quantitative estimate was made of the impacts on the criteria pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Paducah site. McCracken County in the Paducah-Cairo Interstate Air Quality Control Region is currently in attainment for all criteria pollutant standards, including ozone. The pollutants most related to ozone formation that could result from the continued storage options at the Paducah site would be HC and NO_x . The potential effects on ozone of those emissions can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in McCracken County, as recorded in the Kentucky Division of Air Quality Control "Emissions Inventory" for 1995 (Hogan 1996). The estimated maximum annual HC and NO_x emissions of 7.11 and 1.47 tons/yr would be only 1.2 and 0.004%, respectively, of the 1995 McCracken County emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the county.

3.2.4 Water and Soil

Potential water and soil impacts for continued storage of cylinders under the no action alternative were evaluated for surface water, groundwater, and soils at the Paducah site. Impacts to water and soil quality were evaluated by comparisons with EPA guidelines.

Water use for construction under the no action alternative was estimated to be 2 million gal. Operational water use was estimated as ranging from 0.12 to 0.16 million gal/yr.

3.2.4.1 Surface Water

The estimated number of cylinder breaches assumed to occur under the no action alternative is given in Table 3.1; this estimate was used to calculate potential impacts to surface water quality. Each breached cylinder was assumed to release a maximum of 4 lb (1.8 kg) of uranium over a period of 4 years; additional details on the methodology used to evaluate the impacts are given in Appendix C of the PEIS and Tomasko (1997b).

TABLE 3.15 Maximum Concentrations of Criteria Pollutants at Paducah Site Boundaries due to Cylinder Painting^a

Pollutant	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concentration (: g/m ³)	Fraction of Standard ^b	Concentration (: g/m ³)	Fraction of Standard ^b	Concentration (: g/m ³)	Fraction of Standard ^b	Concentration (: g/m ³)	Fraction of Standard ^b
CO	9.48	0.00024	1.19	0.00012	0.396	–	0.0174	–
HC ^c	127	–	15.9	–	5.31	–	0.233	–
NO _x	1.13	–	0.142	–	0.0472	–	0.0021	0.000021
SO _x	2.75	–	0.344	–	0.115	–	0.0050	0.000064
PM ₁₀	0.244	–	0.031	–	0.0102	0.000068	0.00045	0.000009

^a Maximum pollutant concentrations are based on the maximum number of cylinders painted annually under the no action alternative: 3,000 at Paducah.

^b Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

^c HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

TABLE 3.16 Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the Paducah Site under the No Action Alternative

Maximum Number of Breaches Starting in a Single Year	Maximum Total Number of Active Breaches in a Single Year	Maximum HF Concentration (: g/m ³)	
		24-Hour Average	Annual Average
2	5	0.08	0.0093

The estimated maximum uranium concentration in runoff water leaving the yards would be about 20 : g/L (5 pCi/L) for the Paducah site. This concentration would occur in about 2002. The contaminated runoff would then be assumed to flow without loss to the nearest surface water, where it would mix and be diluted. For average flow conditions, the dilution would be large enough that the maximum concentration would be less than 0.3 : g/L (0.2 pCi/L) (Table 3.17). This concentration is less than the EPA proposed drinking water MCL for uranium of 20 : g/L, used here for comparison. The contaminated water would then mix with water in the Ohio River, resulting in even greater dilution. Because of this mixing, impacts to the major rivers would not be measurable.

**TABLE 3.17 Maximum Uranium Concentrations
in Surface Waters for Continued Cylinder Storage
at the Paducah Site under the No Action Alternative**

Receiving Water	Dilution Factor	Maximum Concentration (: g/L)
Little Bayou Creek	124	0.3
Ohio River	43,600	0.000004

3.2.4.2 Groundwater

Groundwater impacts were assessed by assuming that water contaminated due to releases from hypothetical cylinder breaches would leave the yards as runoff and flow to the boundary of the nearest surface water (but not discharge to it), thereby creating a contaminated source on the ground surface. Under the no action alternative, the only impacts to groundwater would be to water quality; no impacts would occur to recharge, depth to water, or direction of flow (see Section 3.3 for discussion of potential impacts based on assuming a greater number of breaches). Conservative estimates of the concentration of uranium in groundwater were obtained by assuming the surface value to be equal to the maximum concentration in water leaving each yard during a time interval of approximately 40 years. This duration corresponds to the time period for the no action alternative. Details on the methodology are given in Appendix C of the PEIS and Tomasko (1997b).

At the end of the no action period (2039), the concentration of uranium in groundwater directly below the edge of the surface contamination at the Paducah site was estimated to be about 0.25 : g/L (Table 3.18), for a retardation factor of 5 (Tomasko 1997b). These concentrations are less than the EPA proposed drinking water MCL for uranium of 20 : g/L (EPA 1996). A maximum concentration of 6 : g/L would occur at the Paducah site around 2070 (Table 3.18). For a retardation factor of 50 (relatively immobile uranium transport), maximum concentrations would be about 10 times less.

3.2.4.3 Soil

The estimated number of cylinder breaches assumed to occur under the no action alternative was used to calculate impacts to soil quality. Each breached cylinder was assumed to release a maximum of 1 lb/yr (0.45 kg/yr) for a maximum of 4 years. For soil, the only impacts would be to

TABLE 3.18 Groundwater Concentrations for Continued Cylinder Storage at the Paducah Site for Two Soil Characteristics under the No Action Alternative^a

Parameter	X = 0			X = 1,000 ft		
	Concentration		Time (yr) at Maximum Concentration	Concentration		Time (yr) at Maximum Concentration
	pCi/L	: g/L		pCi/L	: g/L	
<i>Retardation Factor = 5</i>						
Concentration at 40 years	0.07	0.25				
Maximum concentration	2	6.1	70	1.3	4.9	90
<hr/>						
<i>Retardation Factor = 50</i>						
Maximum concentration	0.2	0.7	585	0.1	0.5	770

^a Retardation factors describe how readily a contaminant such as uranium moves through the soil in groundwater. A retardation factor of 5 represents a case in which the uranium moves relatively rapidly in the soil; a retardation factor of 50 represents a case in which uranium moves slowly.

quality; there would be no impacts to topography, permeability, or erosion potential. Details on these calculations and methodology are presented in Appendix C of the PEIS and Tomasko (1997b).

At the Paducah site, the highest soil concentration of uranium would be 0.1 : g/g in about 2002 for a distribution coefficient (K_d) of 5 (relatively low sorption capacity). If the soil had a larger sorption capacity ($K_d = 50$), the maximum value would be 10 times greater (1.0 : g/g). Even with the larger sorption, soil concentrations at the site would be below the recommended EPA guideline of 230 : g/g for residential soil and 6,100 : g/g for industrial soil (EPA 1995).

3.2.5 Socioeconomics

The impacts of continued storage on regional economic activity were estimated for an ROI around the Paducah site. Additional details regarding the assessment methodology are presented in Appendix C of the PEIS and Allison and Folga (1997).

Current storage activities at the site would likely have a small impact on socioeconomic conditions in the ROI surrounding the site (see Section 2.8). This is partly because a major proportion of expenditures associated with procurement for conducting continued storage activities would flow outside the ROI to other locations in the United States, thereby reducing the concentration of local economic effects of current storage activities at the site.

Slight changes in employment and income would occur in the ROI as a result of local spending derived from employee wages and salaries, local procurement of goods and services required to conduct continued storage activities, and other local investments associated with construction and operations. In addition to creating new (direct) jobs at the site, continued storage would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at the site. Jobs and income created directly by continued storage, together with indirect activity in the ROI, would contribute slightly to a reduction in unemployment in the ROI surrounding the site. Minimal impacts would be expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of continued cylinder storage activities on regional economic activity, measured in terms of employment and personal income, and on population, housing, and local public revenues and expenditures at the Paducah site are discussed in this section. Impacts are presented for the peak year of construction and the peak year of operations. The potential impacts of continued cylinder storage at the site are shown in Table 3.19.

During the peak year for construction and reconstruction of cylinder yards, 20 direct jobs would be created at the site and 60 additional jobs indirectly in the ROI (Table 3.19) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 80 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with \$2.0 million of total income produced during the peak year. During the peak year of continued cylinder storage activities, 90 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, at a total income of \$2.3 million. Continued storage activities would result in an increase of 0.005 percentage points in the projected baseline compound annual average growth rate in ROI employment from 1999 through 2039.

Construction activities would be expected to generate direct in-migration of 20 in the peak year (Table 3.19). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 70 in the peak year. Continued cylinder storage activities would be expected to generate direct and indirect job in-migration of 30 in the peak year of operations and would result in an increase of 0.001 percentage points in the projected baseline compound annual average growth rate in the ROI population from 1999 through 2039.

Continued cylinder storage activities would generate the demand for 20 additional rental housing units during the peak year of construction, representing an impact of 1.6% on the projected number of vacant rental housing units in the ROI (Table 3.19). The demand for 10 additional owner-occupied housing units would be expected in the peak year of operations and would represent an impact of 0.3% on the number of vacant owner-occupied housing units.

TABLE 3.19 Potential Socioeconomic Impacts of Continued Cylinder Storage at the Paducah Site under the No Action Alternative

Parameter	Impacts from Construction ^a	Impacts from Operations ^b
Economic activity in the ROI		
Direct jobs	20	60
Indirect jobs	60	30
Total jobs	80	90
Income (\$ million)		
Direct income	1.0	1.8
Total income	2.0	2.3
Population in-migration into the ROI	70	30
Housing demand		
Number of units in the ROI	20	10
Public finances		
Change in ROI fiscal balance (%)	0.0	0.0

^a Impacts for peak construction year. Construction activities were assumed to occur over 4 years (Parks 1997).

^b Impacts for peak year of operations. Duration of operations was assumed to be 41 years (1999–2039).

During the peak year of construction, 70 persons would in-migrate into the ROI, which would lead to an increase of 0.04% over ROI-forecasted baseline revenues and expenditures (Table 3.19). In the peak year of operations, 30 in-migrants would be expected, which would result in a 0.02% increase in local revenues and expenditures.

3.2.6 Ecology

Impacts to ecological resources during continued cylinder storage would be expected to be negligible. Analysis of potential impacts was based on exposure to airborne contaminants or contaminants released to soil, groundwater, or surface water. Predicted concentrations of contaminants in environmental media were compared to benchmark values of toxic and radiological effects

to assess impacts to terrestrial and aquatic biota. A detailed discussion of assessment methodology is presented in Appendix C of the PEIS.

Atmospheric emissions of criteria pollutants from cylinder storage yard activities — including cylinder painting, cylinder relocation, and new yard construction — would be well below levels harmful to biota, and impacts to ecological resources would be negligible. (See Section 3.2.3 for a discussion of air quality impacts and Appendix C of the PEIS for a discussion of application of predicted values.)

The maximum annual average air concentration of HF at the site boundary, due to hypothetical cylinder breaches, would be very low, about $0.01 : \text{g/m}^3$. Resulting impacts to biota would be expected to be negligible. Potential impacts to ecological resources are shown in Table 3.20.

Soil near the storage yards could become contaminated with uranium by surface runoff from the yards. Uptake of uranium-containing compounds can cause adverse effects to vegetation. The potential maximum uranium concentration in soil would be $1.0 : \text{g/g}$ at the Paducah site (Section 3.2.4.3). Because these estimated concentrations are below the lowest concentration known to produce toxic effects in plants, toxic effects on vegetation due to uranium uptake would not be expected (Table 3.20).

TABLE 3.20 Potential Impacts to Ecological Resources from Continued Cylinder Storage at the Paducah Site under the No Action Alternative

Contaminant	Biota	Maximum Exposure	Effect
Hydrogen fluoride	Wildlife	$0.009 : \text{g/m}^3$	Negligible
Uranium in surface water	Aquatic	$20 : \text{g/L}$	Negligible
		5.2 pCi/L	Negligible
Uranium in groundwater	Aquatic	$6.1 : \text{g/L}$	Negligible
		1.6 pCi/L	Negligible
Uranium in soil	Plants	$1.0 : \text{g/g}$	Negligible

Surface runoff from the storage yards would result in a maximum (undiluted) uranium concentration of 20 : g/L (5.2 pCi/L) at the Paducah site (Section 3.2.4.1). Resulting dose rates to maximally exposed organisms in the nearest receiving surface water body at each site would be negligible. This uranium concentration is also considerably below 150 : g/L, which is the lowest concentration known to adversely affect aquatic biota. Therefore, impacts to aquatic biota would not be expected.

Surface runoff from the storage yards could infiltrate adjacent soil and become a source of groundwater contamination. Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. Groundwater concentrations of uranium near the storage yards could range up to 6.1 : g/L at the Paducah site; uranium activity could range up to 2 pCi/L (Section 3.2.4.2). Resulting toxic effects and dose rates to maximally exposed organisms would be negligible. Resulting impacts to aquatic biota would therefore be negligible (Table 3.20).

Facility accidents (Section 3.2.2) could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of the accident, season, and meteorological conditions.

3.2.7 Waste Management

The principal wastes expected to be generated by operations involving continued cylinder storage are LLW and LLMW. Impacts on waste management from wastes generated during the continued storage operations would be caused by the potential overload of waste treatment and/or disposal capabilities either at a site or on a regional/national scale. Total waste generated from continued cylinder storage under the no action alternative are listed in Table 3.21. Given the types and quantities of waste expected to be generated, there is little potential for impacts on regional or national waste treatment/disposal capabilities.

Only limited construction of additional facilities would be needed to support the operations involved in the continued storage and maintenance of cylinders. No waste management impacts resulting from construction-generated wastes would be expected.

The normal operations to maintain and store cylinders would consist of inspections, stripping and repainting of the cylinders, and disposal of scrap metal from breached cylinders that required emptying. These operations would generate two

TABLE 3.21 Total Waste Generated during Continued Cylinder Storage at the Paducah Site under the No Action Alternative (1999–2039)

Waste (m ³)	
LLW ^a	LLMW ^b
52	893

^a Contaminated scrap metal from breached cylinders that would require emptying.

^b Inorganic process residues from cylinder painting.

primary waste streams: (1) uranium-contaminated scrap metal LLW from breached cylinders and failed valves and (2) solid process residue LLMW from cylinder painting. In the event of cylinder failure, small amounts of additional LLMW could be generated due to releases from breached cylinders.

The amount of LLW generated from continued storage would at most represent less than 1% of site LLW generation (see Section 2.9). The maximum annual amount of LLW generated during the continued storage of cylinders would represent less than 1% of the annual DOE LLW generation.

Continued storage would also generate LLMW. At the Paducah site, stripping/painting operations would generate a maximum annual amount of 23 m³ of LLMW, which would be about 20% of the site's total annual LLMW load, which represents a moderate impact to site waste management capabilities. Overall, impacts from disposal of LLMW could have moderate impacts at the Paducah site. Impacts on national waste management capabilities would be negligible. The input of LLMW from continued cylinder storage at the site would represent less than 1% of the total nationwide LLMW load.

3.2.8 Resource Requirements

The approach taken to assess resource requirements was based on a comparison of required resources with national and state-level statistics on consumption of commodities (U.S. Department of Commerce 1997, 1999). More detailed information related to the methodology is presented in Appendix C of the PEIS.

Material resources that could be consumed during continued cylinder storage include construction materials that could not be recovered or recycled, and materials consumed or reduced to unrecoverable forms of waste. Where construction is necessary, materials required could include concrete, sand, gravel, steel, and other metals. In general, none of the construction resources identified for continued cylinder storage are in short supply, and all would be readily available in the vicinity of the site. Energy resources during construction and operations would include the consumption of diesel fuel and gasoline for construction equipment and transportation vehicles. The anticipated utilities requirements would be within the supply capacities at the site.

Continued cylinder storage would require materials such as 55-gal drums for containment of any generated waste, replacement cylinder valves for those found to be defective upon inspection, and diesel fuel and gasoline to operate equipment and on-site vehicles. In addition, two gallons of paint per cylinder would be required for cylinder painting. Potable water would be made available for the needs of the workforce.

Materials and utilities required for construction and operation activities for continued storage at the Paducah site are presented in Table 3.22. The total quantities of commonly used construction materials are expected to be small compared to local sources. No strategic and critical materials are projected to be consumed for either construction or operations. Small amounts of diesel fuel and gasoline are projected to be used. The required material resources during operations would be readily available.

**TABLE 3.22 Resource Requirements
for Construction and Operations for Continued
Cylinder Storage at the Paducah Site under the
No Action Alternative**

Materials/Resource	Consumption during 1999–2039
<i>Construction</i>	
Solids	
Concrete (yd ³)	20,000
Construction aggregate (yd ³)	29,000
Special coatings (yd ²)	90,000
Liquids (gal)	
Gasoline	3,100
Diesel fuel	18,000
<i>Operations</i>	
Solids	
55-gal drums (each)	104 – 109 ^a
Cylinder valves (1-in.) (each)	9
Liquids (gal/yr)	
Gasoline	3,400 – 4,500
Diesel fuel	8,600 – 13,600
Zinc-based paint	5,700 – 6,000

^a Values reported as ranges generally correspond to varying resource requirements during years for which activities are planned.

3.2.9 Land Use

Other than disturbances to narrow strips of land along the outer perimeters of existing yards, no additional land clearing would be necessary at the Paducah site. Construction activities at Paducah would consist of modifications to existing yards; no new construction would occur outside the footprints of existing yards.

During continued cylinder storage operations, land-use impacts at the site would be negligible and limited to potential minor disruptions on land parcels contiguous to the existing yards. No impacts would be expected for off-site land use.

3.2.10 Cultural Resources

Impacts to cultural resources are not likely at the Paducah site during continued cylinder storage. The existing and proposed storage yards at Paducah are located in previously disturbed areas unlikely to contain cultural properties or resources eligible for the *National Register of Historic Places*.

3.2.11 Environmental Justice

The analysis of potential environmental justice impacts resulting from continued cylinder storage is based on the conclusions drawn in the assessment of impacts on human health (Sections 3.2.1 and 3.2.2) and a review of environmental impacts presented in discussions of other technical areas (Sections 3.2.3 through 3.2.10) such as air quality, water quality and soils, socioeconomics, and ecological resources. The analysis of health effects included an examination of risks to the general public associated with normal facility operations and accidents. A detailed description of the mapping procedures, screening criteria, calculational methods, and demographic sector analysis is presented in Appendix C, Section C.8, of the PEIS.

Events occurring after 2039 could not be included in the analysis of potential environmental justice impacts because the composition of the population residing within 50 miles (80 km) of a site cannot be projected with accuracy over the long term. Current minority and low-income population proportions for the site were assumed out to the year 2039.

A review of potential human health impacts (Sections 3.2.1 and 3.2.2) indicated that no high and adverse human health effects or impacts would be expected from continued storage of cylinders at the Paducah site. Therefore, although minority and low-income populations reside within 50 miles (80 km) of the site, no disproportionate impacts would be expected. The distributions of minority and low-income population census tracts within a 50-mile (80-km) radius of the site are

shown in Figure 2.4. Screening criteria limits (Appendix C, Section C.8, of the PEIS) for radiological and chemical sources under normal operations and accident conditions were not exceeded, and the risk of fatalities from operations and accidents from 1999 through 2039 would be considerably below 1. Radiological releases from normal operations at the site would result in an annual average dose to the MEI residing outside the facility that would be considerably below the DOE regulatory limit of 100 mrem/yr for members of the public. Chemical impacts from routine operations under continued storage at the Paducah site would result in an MEI hazard index well below 1. Additionally, accidental chemical releases would not result in any expected fatalities or expected adverse human health effects for the general public (when considering risk, i.e., the product of the potential number of persons affected and the probability of the accident occurring).

A review of impact assessments for other technical areas (Sections 3.2.3 through 3.2.10) indicated that few or no impacts would be expected from continued storage of cylinders at the site. Projected air emissions from construction activities and operations would be below federal and state regulatory limits and no impacts to water quality or soils are anticipated. Consequently, no segment of the population, including minorities or persons of low-income, would experience disproportionate impacts.

3.2.12 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur as a result of continued storage of depleted UF₆ cylinders at the site include impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, as well as impacts associated with decontamination and decommissioning of the storage yards. These impacts, although considered, were not analyzed in detail because the impacts would be negligibly small or consideration of the impacts would not contribute to differentiation among the alternatives and therefore would not affect the decisions to be made in the ROD to be issued following publication of the PEIS.

3.3 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE BASED ON UNCERTAINTIES IN CORROSION CONTROL

Under the no action alternative, it was assumed that cylinders would be painted every 10 years and that the paint would effectively stop any further corrosion of the cylinders (see introduction to Section 3). To address uncertainty in both the effectiveness of the painting in controlling further corrosion and uncertainties in the future painting schedule, a conservative assessment was made of the impacts assuming that painting would have no effect on corrosion. Under this assumption and using historical data, the number of breaches that would occur at the site as a function of time were estimated (Lyon 1997). These conservative estimates indicate that the

number of breaches that could occur prior to 2039 would be about 400 at the Paducah site (see Table 3.2).

If no credit were taken for corrosion reduction through painting, and if storage was continued indefinitely, calculations indicate that uranium releases from breaches occurring at the Paducah site prior to about the year 2020 could result in a sufficient amount of uranium in the soil column to bring the groundwater concentration of uranium to 20 : g/L in the future (about year 2100 or later) (Tomasko 1997a).

Also, if no credit were taken for corrosion reduction through painting, it is possible that air quality concerns might arise. The maximum estimated 24-hour average HF concentration at the Paducah site boundary through the year 2039 would be 2 : g/m³, well below the State of Kentucky primary standard for HF of 816 : g/m³ maximum 24-hour average.

A painting program for the cylinders, designed to control further corrosion, has been initiated at the Paducah site. Therefore, the assumption of uncontrolled corrosion is not a reasonable assumption. The painting program is expected to eliminate or substantially reduce the corrosion of cylinders at the sites. DOE will continue to monitor its cylinders and is committed to maintain the safety basis of continued cylinder storage. If the conditions became substantially different from what is assumed under the no action alternative, DOE would take the appropriate action(s) to maintain the safety basis.

3.4 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE FOR THE ACTION ALTERNATIVES

For the action alternatives considered in the PEIS — long-term storage as UF₆, long-term storage as UO, use as UO, use as uranium metal, and disposal as UO — continued storage could be necessary for some portion of the DOE-generated cylinders at the current storage sites through approximately 2028 (through 2034 when USEC-generated cylinders are considered — see Section 3.5). This 30-year storage period would correspond to the period during which construction of conversion, long-term storage, and/or disposal facilities would occur and during which the cylinders would be transported from the current locations to the processing locations. For analyses in the PEIS, the cylinder removal period was assumed to take place between 2009 and 2028; the number of cylinders at each site would decrease by 5% annually during that time.

Potential environmental impacts associated with continued cylinder storage for the action alternatives were assessed with essentially the same methodology used to estimate impacts for the no action alternative (see Section 3.2 of this report and Appendix C of the PEIS). Through the year 2008, the number of maintenance activities (such as inspections, yard reconstruction, and painting) was assumed to be the same as for the no action alternative (Parks 1997). From 2009 through 2028,

the number of maintenance activities was assumed to decrease by 5% annually, to correspond to the reduction in cylinder inventory that would be occurring. Impacts associated with maintenance activities (e.g., radiation doses to involved workers) would, therefore, generally be reduced for the action alternatives.

A key difference between the assessment of continued storage impacts conducted for the action alternatives and the assessment conducted for the no action alternative was in the assumptions made regarding potential numbers of breached cylinders. Because of impending cylinder movement or content transfer, cylinder yard improvement and cylinder painting might not occur at the same rate under the action alternatives as they would under the no action alternative. Because the painting schedule that would be followed under the action alternatives is not known, and to present reasonable upper bound estimates of impacts, no credit was taken for the effectiveness of cylinder yard improvements and painting in reducing cylinder corrosion rates. Therefore, the number of hypothetical cylinder breaches assumed for the action alternatives was estimated by assuming that painting and improved storage conditions were not effective in arresting continued corrosion of the cylinders (i.e., assuming that corrosion continued at historical rates) and by assuming that the population of cylinders at the site was decreasing at an annual rate of 5% between the years 2009 and 2028. This assumption led to a higher number of assumed breaches for continued storage under the action alternatives than under the no action alternative, even though the number of years of storage would be fewer. The assumptions for releases of uranium and HF from breached cylinders, as well as for methods to estimate water and soil impacts, were identical to those used for the assessment of impacts for the no action alternative. However, the outcome of the increased number of assumed cylinder breaches was a slightly higher estimate of impacts on groundwater, air quality, and human health and safety for the action alternatives, although the estimated impacts are still within applicable standards or guidelines (see Table 3.3). The impacts of continued cylinder storage under the action alternatives for the various technical areas of interest are discussed in Sections 3.4.1 through 3.4.11. Assessment methods are described in Appendix C of the PEIS.

3.4.1 Human Health — Normal Operations

3.4.1.1 Radiological Impacts

Estimated radiation doses and latent cancer risks for the site are presented in Tables 3.23 and 3.24. Long-term radiological impacts (based on groundwater contamination) are provided in Table 3.25.

During the continued cylinder storage period (1999–2028), the average annual collective dose for involved workers would be about 15 person-rem/yr for an average of 23 workers, assuming the workers work 5 hours per day in the cylinder yard. The individual dose for involved workers

TABLE 3.23 Radiological Doses from Continued Cylinder Storage under Normal Operations at the Paducah Site for the Action Alternatives

Annual Dose to Receptor					
Involved Workers ^a		Noninvolved Workers ^b		General Public	
Average Individual Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose ^c (mrem/yr)	Collective Dose ^d (person-rem/yr)	MEI Dose ^e (mrem/yr)	Collective Dose ^f (person-rem/yr)
650	15	0.26	0.012	0.031 (< 0.072)	0.017

^a Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. The reported values are averages over the time period 1999–2028. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

^b Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

^c The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest dose. The reported values are the maximums over the time period considered.

^d The reported collective doses are averages over the time periods considered. Population size of the noninvolved workers was assumed to be about 2,000 for the Paducah site.

^e The MEI for the general public was assumed to be located off-site at a point that would yield the largest dose. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

^f Collective dose was estimated for the population within a radius of 50 miles (80 km) around the site. The reported values are averages over the time period considered. The off-site population is 500,000 persons for Paducah. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE 3.24 Latent Cancer Risks from Continued Cylinder Storage under Normal Operations at the Paducah Site for the Action Alternatives

Annual Risk of Latent Cancer Fatality to Receptor					
Involved Worker ^a		Noninvolved Worker ^b		General Public	
Average Individual Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk ^c (risk/yr)	Collective Risk ^d (fatalities/yr)	MEI Risk ^e (risk/yr)	Collective Risk ^f (fatalities/yr)
3×10^{-4}	6×10^{-3}	1×10^{-7}	5×10^{-6}	2×10^{-8} ($< 7 \times 10^{-9}$)	8×10^{-6}

^a Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population. The reported values are averages over the time period 1999–2028.

^b Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

^c The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest risk. The reported values are the maximums over the time period considered.

^d The reported collective risks are averages over the time period considered. Population size of the noninvolved workers was assumed to be about 2,000 for the Paducah site.

^e The MEI for the general public was assumed to be located off-site at a point that would yield the largest risk. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

^f Collective risk was estimated for the population within a radius of 50 miles (80 km) around the site. The reported values are averages over the time period considered. The off-site population is 500,000 persons for Paducah. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

would average 650 mrem/yr for this period of time. The maximum dose for noninvolved workers would be less than 0.3 mrem/yr, well below the regulatory limit of 10 mrem/yr. For the general public, the maximum dose would be approximately 0.1 mrem/yr, with 0.03 mrem/yr from airborne pathways and 0.07 mrem/yr from groundwater pathways.

Long-term radiation exposure after year 2028 from use of contaminated groundwater would result in a maximum dose of 1.3 mrem/yr, which is a small fraction of the DOE dose limit of 100 mrem/yr for the general public.

3.4.1.2 Chemical Impacts

Chemical impacts associated with continued cylinder storage could result primarily from exposure to uranium compounds and HF released from hypothetical cylinder breaches. Estimated impacts for the site are given in Table 3.26. The highest hazard quotients result when the use of contaminated groundwater is considered in addition to exposures through inhalation, soil ingestion, and surface water ingestion (i.e., maximum hazard quotient of 0.17). Adverse health effects would not be expected from exposure to chemical contaminants associated with continued cylinder storage (that is, the estimated hazard indices would all be less than the threshold value of 1).

3.4.2 Human Health — Accident Conditions

The assessment of impacts conducted for potential accidents associated with continued cylinder storage under the action alternatives was similar to that for the no action alternative (Section 3.2.2) in that the same accidents were considered and the consequences of those accidents would be the same. However, because the duration of continued cylinder storage under the action alternatives is 11 years shorter than that assessed for the no action alternative (i.e., 30 years assumed

TABLE 3.25 Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage at the Paducah Site under the Action Alternatives^{a,b}

Impact to MEI of General Public	
Radiation Dose ^c (mrem/yr)	Latent Cancer Risk ^c (risk/yr)
0.13 – 1.3	$6 \times 10^{-8} - 7 \times 10^{-7}$

^a Long-term impacts correspond to the time after the year 2028.

^b Long-term impacts would be caused by the potential use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. Contamination of groundwater would result from releases from hypothetically breached cylinders and the resulting infiltration of UO_2F_2 to the deeper soils, eventually reaching the groundwater (UO_2F_2 is the product of UF_6 reacting with moisture in air).

^c Radiation doses and latent cancer risks are expressed as ranges, which would result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2028, assuming no mitigation action was taken.

TABLE 3.26 Chemical Impacts to Human Health from Continued Cylinder Storage under Normal Operations at the Paducah Site for the Action Alternatives

Time Period	Impacts to Receptor			
	Noninvolved Workers ^a		General Public ^b	
	Hazard Index ^c for MEI	Population Risk ^d (ind. at risk/yr)	Hazard Index ^c for MEI	Population Risk ^d (ind. at risk/yr)
1999–2028	1.6×10^{-3}	–	5.2×10^{-3} (9.0×10^{-3})	–
Long term ^e	NA ^f	–	0.02 – 0.17	–

^a Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. The MEI for the noninvolved worker was assumed to be at the on-site (outside storage yards) location that would yield the largest exposure. Exposures would result from airborne emissions of UO₂F₂ and HF from hypothetically breached cylinders; the exposure pathways considered included inhalation and incidental ingestion of soil.

^b The MEI for the general public was assumed to be located off-site at the point that would yield the largest exposure. Results reported are the maximum values for the time period considered and would result from exposure via inhalation; ingestion of soil (resulting from airborne emissions of UO₂F₂ and HF from hypothetically breached cylinders); and drinking surface water (consequence of the discharge of contaminated runoff water to a surface water body). Potential impacts during the storage period 1999–2028 (values within parentheses) were also evaluated from the use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

^c The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

^d Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

^e Long-term impacts would result from using contaminated groundwater.

^f NA = not applicable; workers were assumed not to ingest groundwater.

for the action alternatives compared with 41 years assumed for the no action alternative), the risk of these accidents occurring would therefore be somewhat lower under the action alternatives.

The activities considered in calculating the physical hazards associated with continued cylinder storage were routine cylinder inspections, ultrasonic inspections, valve monitoring and maintenance activities, cylinder relocations, cylinder yard construction or reconstruction, cylinder painting, and patching and content transfers of breached cylinders. These activities were assumed to continue through the year 2039, except for yard construction and reconstruction, which were assumed to be complete by the year 2003. The annual labor requirements and the corresponding fatality and injury risks to all workers for these activities were estimated to be as follows: the fatality incidence at the Paducah site would be less than 0.03, and the injury incidence would be about 41 injuries.

3.4.3 Air Quality

The assessment of air quality impacts from construction, relocating cylinders, and painting cylinders conducted for the no action alternative would also be applicable for the action alternatives because the assessment was based on maximum annual impacts (i.e., the same construction activities were assumed, as well as the same levels of relocating and painting cylinders during the initial years of continued storage). Potential impacts on air quality from these activities are discussed in Section 3.2.3.

The estimated HF emissions for the action alternatives would differ from those for the no action alternative because different numbers of breached cylinders were assumed. The numbers of hypothetical breaches and estimated resulting HF concentrations at the site are given in Table 3.27. The estimated 0.27-: g/m^3 maximum 24-hour average HF concentration for the Paducah site is considerably below the Kentucky primary standard of 816 : g/m^3 (1.0 ppm).

3.4.4 Water and Soil

3.4.4.1 Surface Water

The estimated number of cylinder breaches assumed to occur during continued cylinder storage for the action alternatives (see Section 3.4) was used to calculate potential impacts to surface water quality. Each breached cylinder was assumed to release a maximum of 4 lb (1.8 kg) of uranium over 4 years; additional details on the methodology used to evaluate the impacts are given in Appendix C of the PEIS and Tomasko (1997b).

TABLE 3.27 Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the Paducah Site for the Action Alternatives

Maximum Number of Breaches Starting in a Single Year	Maximum Total Number of Active Breaches in a Single Year	Maximum HF Concentration (: g/m ³)	
		24-Hour Average	Annual Average
4	16	0.27	0.03

The estimated maximum uranium concentration in runoff water leaving the yards would be about 121 : g/L (31 pCi/L) for the Paducah site. This concentration would occur in about the year 2018. After leaving the yards, the contaminated runoff was assumed to flow without loss to the nearest surface water, where it would mix and be diluted. For average flow conditions, the dilution would be large enough that the maximum concentration would be less than 2 : g/L (0.5 pCi/L) for the site (see Table 3.28). This concentration is less than the EPA proposed drinking water MCL for uranium of 20 : g/L, used here for comparison. The contaminated water would then mix with water in the Ohio River, which would result in even greater dilution. Because of this mixing, impacts to the major river would not be measurable.

3.4.4.2 Groundwater

Methods for estimating groundwater impacts were the same as those used for the no action alternative (Section 3.2.4.2); however, a larger number of cylinder breaches was assumed to occur. Conservative estimates of the concentrations of uranium in groundwater were obtained by assuming the surface value to be equal to the maximum concentration in water leaving each yard during a time interval of approximately 20 years; this time interval corresponds to the time over which the concentration in surface water would be higher than half of its maximum value.

At the end of the time period considered for the action alternatives (1999–2028), the concentration of uranium in groundwater directly below the edge of the surface contamination at the Paducah site is estimated to be about 1.1 : g/L (0.3 pCi/L), for a retardation factor of 5 (Table 3.29) (Tomasko 1997b). This concentration is less than the proposed EPA drinking water MCL for uranium of 20 : g/L, used here for comparison (EPA 1996).

TABLE 3.28 Maximum Uranium Concentrations in Surface Waters for Continued Cylinder Storage at the Paducah Site under the Action Alternatives

Receiving Water	Dilution Factor	Maximum Concentration (: g/L)
Big Bayou Creek	124	1.7
Ohio River	43,600	0.00002

TABLE 3.29 Groundwater Concentrations for Continued Cylinder Storage for Two Soil Characteristics at the Paducah Site under the Action Alternatives^a

Parameter	X = 0			X = 1,000 ft		
	Concentration		Time (yr) to Maximum Concentration	Concentration		Time (yr) to Maximum Concentration
	pCi/L	: g/L		pCi/L	: g/L	
<i>Retardation Factor = 5</i>						
Concentration at 30 years	0.28	1.1				
Maximum concentration	5.2	20	>70	4.0	16	>70
<hr/>						
<i>Retardation Factor = 50</i>						
Maximum concentration	0.5	2.1	>500	0.4	1.6	>500

^a Retardation factors describe how readily a contaminant such as uranium moves through the soil in groundwater. A retardation factor of 5 represents a case in which the uranium moves relatively rapidly in the soil; a retardation factor of 50 represents a case in which uranium moves slowly.

A maximum concentration of about 20 : g/L (5 pCi/L) would occur between the years 2070 and 2080 at the Paducah site, assuming a retardation factor of 5. The maximum concentration would equal the EPA proposed drinking water guideline; however, this guideline is not directly applicable because the groundwater directly at the boundary of the nearest surface water is unlikely to be used as a drinking water source. For a retardation factor of 50 (relatively immobile uranium transport), the maximum concentration would be about 10 times less. This concentration would occur between the years 2500 and 2700.

Assuming a retardation factor of 5 and a distance of 1,000 ft (300 m) from the edge of the source area, the maximum concentration of uranium would be about 16 : g/L (4 pCi/L) at the Paducah site. For less mobile conditions (retardation of 50), the maximum concentration would be about 10 times less.

3.4.4.3 Soil

The maximum uranium concentration in soil for a distribution coefficient of 50 (relatively high sorption capacity) would be less than 7 : g/g. If the soil had a lower sorption capacity (distribution coefficient of 5), the soil concentration would be about 10 times lower. This maximum soil concentration associated with continued cylinder storage under the action alternatives is much lower than the recommended EPA guideline level of 230 : g/g for residential soil or 1,000 : g/g for industrial soil (EPA 1995).

3.4.5 Socioeconomics

The methods used to assess socioeconomic impacts of continued cylinder storage for the action alternatives were the same as those used for the no action alternative (Section 3.2.5). Impacts are presented in Table 3.30. Construction impacts would be identical to those estimated for the no action alternative because all construction would take place during the time period 1999–2008, when identical activities are assumed. Under the action alternatives, continued storage activities would still have a negligible impact on socioeconomic conditions in the ROIs surrounding the site.

3.4.6 Ecology

For continued cylinder storage under the action alternatives, the maximum annual average HF concentration would be 0.03 : g/m³ for the Paducah site (Section 3.4.3). Resulting impacts to biota would be expected to be negligible. Contamination of soils near the storage yards by surface

TABLE 3.30 Potential Socioeconomic Impacts of Continued Cylinder Storage at the Paducah Site under the Action Alternatives

Parameter	Impacts from Construction ^a	Impacts from Operations ^b
Economic activity in the ROI		
Direct jobs	20	60
Indirect jobs	60	30
Total jobs	80	90
Income (\$ million)		
Direct income	1.0	1.7
Total income	2.0	2.2
Population in-migration into the ROI	70	30
Housing demand		
Number of units in the ROI	20	10
Public finances		
Change in ROI fiscal balance (%)	0.0	0.0

^a Impacts for peak construction year. Construction activities were assumed to occur over 4 years (1999–2002) at the Paducah site.

^b Impacts for peak year of operations. Duration of operations was assumed to be 30 years (1999–2028).

runoff could result in a maximum uranium concentration of 6.1 : g/g at the Paducah site (Section 3.4.4). The predicted concentration for the site is approximately the same as the lowest uranium concentration known to produce toxic effects in plants (5 : g/g). The extent of vegetation affected would be restricted to the area of surface runoff from the yards. Therefore, impacts to vegetation would be expected to be negligible to low. Surface runoff from the storage yards would have a maximum uranium concentration of 121 : g/L (31 pCi/L) at the Paducah site (Section 3.4.4). Resulting impacts to maximally exposed organisms in the nearest receiving surface water body at the site would be expected to be negligible. Uranium concentrations in groundwater would be considerably less and resulting impacts to aquatic biota would be negligible.

Uranium concentrations in groundwater following the cylinder removal period would be very low, and long-term impacts to aquatic biota would not be expected. Contaminants associated

with cylinder storage would not occur in other environmental media following the cylinder removal period.

3.4.7 Waste Management

As for the no action alternative, the principal wastes that are expected to be generated during continued cylinder storage are uranium-contaminated scrap metal from breached cylinders and failed valves, assumed to be LLW, and solid process residue from cylinder painting, assumed to be LLMW. The total amounts of these waste types estimated to be generated for continued cylinder storage under the action alternatives is given in Table 3.31. The annual amount of LLW generated would be less than 2% of current site LLW generation. The maximum annual amount of LLW generated during continued cylinder storage would represent less than 1% of the annual DOE LLW generation.

For the Paducah site, the annual amount of LLMW generated during the initial years of evaluation, when painting of the entire inventory was assumed to occur (23 m³/yr), would represent about 20% of the site's total annual LLMW load, a moderate impact on site waste management capabilities. The input of LLMW from continued storage would represent less than 1% of the total nationwide LLMW load. Overall, impacts from disposal of LLMW could have moderate impacts at the Paducah site. Impacts on national waste management capabilities would be negligible.

TABLE 3.31 Total Waste Generated at the Paducah Site during Continued Cylinder Storage under the Action Alternatives (1999–2028)

Waste (m ³)	
LLW ^a	LLMW ^b
792	440

^a Contaminated scrap metal from breached cylinders that would require emptying.

^b Inorganic process residues from cylinder painting.

3.4.8 Resource Requirements

Resource requirements for continued cylinder storage under the action alternatives are summarized in Table 3.32. The resource requirements for construction would be identical to those for the no action alternative (see Section 3.2.8). The upper end of the range of annual requirements shown in Table 3.32 generally corresponds to the upper end of the range estimated for the no action alternative; these requirements represent the early years of continued cylinder storage when some construction activities are planned. The lower end of the range of annual resource requirements is lower than the lower values for the no action alternative because maintenance of the decreasing cylinder inventory would require fewer resources.

**TABLE 3.32 Resource Requirements
for Construction and Operations for Continued
Cylinder Storage at the Paducah Site under the
Action Alternatives**

Materials/Resource	Consumption during 1999–2028
<i>Construction</i>	
Solids	
Concrete (yd ³)	20,000
Construction aggregate (yd ³)	29,000
Special coatings (yd ²)	90,000
Liquids (gal)	
Gasoline	3,100
Diesel fuel	18,000
<i>Operations^a</i>	
Solids	
55-gal drums (each)	53 – 109
Cylinder valves (1-in.) (each)	4 – 9
Liquids (gal/yr)	
Gasoline	2,000 – 4,500
Diesel fuel	4,300 – 13,600
Zinc-based paint	2,900 – 6,000

^a Values reported as ranges generally correspond to varying resource requirements during years for which activities are planned.

The total quantities of commonly used construction materials needed for continued storage under the action alternatives are expected to be small compared with local sources. No strategic and critical materials are projected to be consumed for either construction or operations. Small amounts of diesel fuel and gasoline are projected to be used. The required material resources during operations would appear to be readily available.

3.4.9 Land Use

Construction activities assumed for continued storage under the action alternatives are identical to those assumed for the no action alternative. Therefore, potential land-use impacts would be the same as those discussed in Section 3.2.9.

3.4.10 Cultural Resources

Potential impacts to cultural resources under the action alternatives would be identical to those discussed in Section 3.2.10.

3.4.11 Environmental Justice

Because no screening criteria limits for radiological and chemical sources under normal operations were exceeded under the action alternatives, no disproportionate impacts to minority and low-income populations would be associated with normal operations for continued cylinder storage. The assessment of impacts for potential accidents associated with continued cylinder storage under the action alternatives is similar to that for the no action alternative (Section 3.2.11) in that the same accidents were considered and the consequences of those accidents would be the same. However, because the duration of continued cylinder storage under the action alternatives is 11 years shorter than that assessed for the no action alternative (i.e., 30 years assumed for the action alternatives compared with 41 years assumed for the no action alternative), the risk of these accidents occurring is somewhat lower. However, the conclusion that no disproportionate impacts would be associated with continued cylinder storage under the no action alternative is still applicable for the action alternatives because risks are lower for these alternatives.

3.5 POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH CONTINUED STORAGE OF THE ENTIRE PADUCAH SITE CYLINDER INVENTORY

After the draft PEIS was completed, management responsibility for approximately 8,600 additional cylinders of depleted UF₆ at the Paducah site was transferred from USEC to DOE by the signing of two MOAs associated with the privatization of USEC (DOE and USEC 1998a,b). About 6,600 of these cylinders are currently stored in the C-745-C, Q, and R-yards at the Paducah site (see Section 2.1.1 and Figure 2.2). The additional 2,000 cylinders were assumed to be located in these same yards in the PEIS. To account for uncertainties associated with the number of cylinders that would be transferred from USEC to DOE in the future and to provide a bounding analysis of environmental impacts, the final PEIS evaluated the environmental impacts of managing an additional 12,000 cylinders at the Paducah site. These analyses are summarized in Chapter 6 of the PEIS; impacts associated with continued cylinder storage under both the no action alternative and the action alternatives are summarized in this section.

3.5.1 Approach Used to Evaluate the Environmental Impacts of Continued Storage of the USEC Cylinders

Management of the USEC-generated cylinders must conform with all requirements applicable to the DOE-generated cylinders. These requirements are described in the UF₆ cylinder project management plan (LMES 1997d). For the site-specific evaluation of continued storage of the USEC-generated cylinders, it was assumed that the USEC cylinders would be managed in the same way as were the DOE-generated cylinders. Management activities would include (1) refurbishment of cylinder yards and restacking as necessary, (2) routine and ultrasonic testing inspections of cylinders and valve monitoring and maintenance, (3) cylinder painting as necessary, and (4) repair and/or removal of the contents of any cylinders that might be breached during the storage period.

In general, the USEC-generated cylinders are newer than the DOE-generated cylinders and do not exhibit the heavy external corrosion that can result from long-term storage in substandard conditions. Moreover, since these cylinders would be regularly inspected and maintained while under DOE management, future external corrosion would be expected to be minimal. Nonetheless, for the purpose of analyzing continued cylinder storage impacts in the PEIS, the USEC-generated cylinders were assumed to be essentially the same as the DOE-generated cylinders; i.e., the rate of corrosion and the cylinder breach rate were assumed to be the same.

For the PEIS, under the no action alternative, potential environmental impacts were estimated from continued cylinder storage through the year 2039. Under the action alternatives (long-term storage as UF₆, long-term storage as oxide, use as oxide, use as metal, and disposal as oxide), it was assumed that continued cylinder storage would extend from 2009 through 2028 at the current

storage sites. The inclusion of the USEC-generated cylinders would increase the length of some continued storage at the Paducah site from the year 2028 through about the year 2034. On the basis of the assumption that the rate of cylinder breaches would be the same for the USEC-generated cylinders as for the DOE-generated cylinders, it was estimated that the number of cylinder breaches would increase by 42% at the Paducah site. (This increase corresponds directly to the increase in the cylinder inventory at the site.) These assumptions were applied to estimate the number of breaches that would occur in two cases: (1) if painting the cylinders controlled future corrosion and (2) if corrosion continued at the historic rate. For corrosion-induced breaches, these are very conservative assumptions (i.e., are likely to result in overestimates of the number of breaches), because the USEC-generated cylinders are newer than the DOE cylinders.

3.5.2 Potential Environmental Impacts from Continued Storage of the Entire Cylinder Inventory (DOE- and USEC-Generated Cylinders) under the No Action Alternative

3.5.2.1 Human Health and Safety — Normal Operations

3.5.2.1.1 Workers

In general, the continued cylinder storage of the additional USEC cylinders at the Paducah site would increase the overall level of activity of involved workers by approximately 40%, resulting in a corresponding increase in the total radiation dose to the worker population over the duration of the program (total dose of about 1,300 person-rem). However, this increase in the radiation dose would not change the estimate of less than 1 LCF among workers at the Paducah site under the no action alternative. In addition, the average annual radiation dose to individual workers associated with management of the additional USEC-generated cylinders would be the same as that reported for the management of DOE-generated cylinders only, because additional cylinder yard workers would be used to perform the necessary activities instead of having the same individuals conduct extra activities. Thus, the number of involved workers at the Paducah site would increase from about 30 to 43, but the average annual doses to involved workers at the site would remain at about 740 mrem/yr.

The management of USEC-generated cylinders would result in a potential increase in the radiation dose to noninvolved workers from airborne releases that would be proportional to the increase in the total cylinder inventory and number of hypothetical cylinder breaches (i.e., the collective dose would increase by approximately 40%, to a total of about 0.13 person-rem). The increase in dose to the noninvolved worker MEI at the Paducah site would be insignificant (i.e., increase of 0.04 mrem/yr to a total dose of 0.15 mrem/yr). Also, the change in the potential for

noncancer health effects from exposure to airborne uranium and HF releases would be such that the hazard index for the noninvolved worker MEI would remain less than 0.1.

3.5.2.1.2 General Public

The management of USEC-generated cylinders would result in a potential increase in the radiation dose to the public from airborne releases that would be proportional to the increase in the total cylinder inventory and number of hypothetical cylinder breaches (i.e., the dose would increase by approximately 40%, to a total of about 0.3 person-rem). This level of exposure would remain well below levels expected to cause any adverse effects.

The increase in maximum radiation dose to an individual near the Paducah site would be insignificant (total dose less than 0.1 mrem/yr). Also, the change in the potential for noncancer health effects from exposure to airborne uranium and HF releases would be such that the maximum hazard index for an individual would remain less than 0.1.

The estimated maximum uranium concentration in groundwater and resulting health effects among member of the public from future cylinder breaches would be the same as that estimated for the management of DOE-generated cylinders (Section 3.2.4.2), because the estimated groundwater concentration for the DOE-generated cylinders was calculated on the basis of hypothetical breaches occurring in the G-yard at the Paducah site. This assumption represents a worst-case scenario in terms of groundwater contamination; additional breaches from USEC cylinders stored in different yards would not increase the estimated groundwater concentrations.

3.5.2.2 Human Health and Safety — Accident Conditions

3.5.2.2.1 Physical Hazards

The total number of worker fatalities and injuries associated with continued storage through 2039 of the entire inventory at the Paducah site (including USEC cylinders) would be 0.09 fatality and about 100 injuries.

3.5.2.2.2 Accidents Involving Releases of Radiation or Chemicals

For accident consequences, impacts would be the same as those previously discussed for the DOE-generated cylinders (Section 3.2.2), because the types of accidents assessed would involve only a limited amount of material that would be at risk under accident conditions regardless of the

number of cylinders in storage (for example, a vehicle-induced fire would be estimated to involve three full cylinders regardless of the number of cylinders at the site). Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC-generated cylinders (e.g., cylinder handling accidents), this increase is not expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used in the PEIS (i.e., likely = greater than or equal to 1 time in 100 years; unlikely = between 1 time in 100 years and 1 time in 10,000 years; extremely unlikely = between 1 time in 10,000 years and 1 time in 1 million years; incredible = less than 1 time in 1 million years).

3.5.2.3 Transportation

The continued storage of the USEC-generated cylinders would result in small additional quantities of LLW and LLMW requiring shipment annually (from cylinder monitoring and maintenance activities). This additional waste would result in less than one additional waste shipment each year. Because of the small number of shipments and the low concentrations of contaminants expected, the potential environmental impacts from these shipments would be negligible.

3.5.2.4 Air Quality

Continued storage of the USEC-generated cylinders will require refurbishment of the storage yards used for these cylinders. The paving of these yards would result in PM_{10} emissions (i.e., dust). For the continued storage of DOE-generated cylinders at the Paducah site (Section 3.2.3), potential PM_{10} emissions during construction activities would approach regulatory standards. This would also be the case during refurbishment of the yards used for USEC-cylinder storage. Emissions would be expected to be less than or equal to those estimated for the DOE-generated cylinders, because refurbishment of cylinder yards would be conducted sequentially, and the yards used for storage of USEC-generated cylinders and requiring refurbishment would be approximately the same size and in the same general location as the yards being used for DOE-generated cylinder storage. Mitigative measures, such as water spraying, might be required to reduce the PM_{10} emissions during refurbishment of cylinder yards for both DOE- and USEC-generated cylinders.

The overall site emissions of criteria pollutants would increase as a result of the continued storage of USEC cylinders; however, the resulting concentrations would remain well below regulatory standards. Painting the USEC-generated cylinders to protect them from external corrosion, as needed, would also not have a significant impact on regional ozone formation.

Potential emissions of HF due to hypothetical breaches of some USEC-generated cylinders were estimated to remain well within applicable standards and guidelines at the Paducah site, whether or not corrosion control was assumed.

3.5.2.5 Water and Soil

Construction activities associated with refurbishment of USEC storage yards would be limited and occur in previously developed areas; therefore, impacts in assessment areas — such as changes in runoff, recharge to underlying aquifers, and changes in soil permeability or erosion potential — would be expected to be very minimal. Additional water use for continued storage of USEC-generated cylinders was roughly estimated to be 0.8 million gal for construction and 67,000 gal/yr for operations at the Paducah site. Total water use would be 3 million gal for construction and 230,000 gal/yr for operations at Paducah.

Releases from hypothetical breaches of the USEC cylinders would, in general, increase concentrations in groundwater in some areas of the site (i.e., in the areas near or in USEC cylinder storage yards). However, maximum concentrations calculated for evaluating the worst-case impacts to groundwater at the Paducah site (G-yard) under the no action alternative would remain the same as those described in Section 3.2.4.2. These concentrations would not change because the number of cylinders at the G-yard would be the same (USEC cylinders would be stored at other yards) and because, in the groundwater modeling method used, contaminant plumes emanating from the vicinity of the yards are assumed to be independent and not interact because of the distance separating the yards, the short travel distance to the assumed receptor (i.e., 1,000 ft), and limited plume spreading caused by lateral dispersion. Therefore, although concentrations of uranium in groundwater beneath some cylinder storage yards would increase because of the addition of the USEC cylinders, the maximum concentrations for the entire site would still be represented by the values given in Section 3.2.4.2 (i.e., 6 : g/L).

The maximum concentration in surface water bodies adjacent to the sites would also stay about the same (0.3 : g/L) because of dilution in these water bodies. For soil, the worst-case concentration would remain the same (about 1 : g/g); runoff from the USEC yards would not mix with runoff from the G-yard at Paducah to increase local soil contaminant concentrations.

3.5.2.6 Socioeconomics

Additional construction activities that would result from the addition of USEC-generated cylinders at the Paducah site would generate approximately 8 additional direct jobs and about 34 additional total (direct and indirect) jobs. Operational activities at the Paducah site would create 25 additional direct jobs and 38 additional total jobs per year. Direct additional income from

construction at the Paducah site in the peak year would be \$0.4 million, and total additional income in the peak year would be \$0.8 million. During operations, additional direct and total income at the Paducah site would be \$0.8 million and \$1 million per year, respectively.

The total socioeconomic impacts from continued cylinder storage at the Paducah site (when both DOE- and USEC-generated cylinders are considered) would be 28 direct jobs and 114 total jobs in the peak construction year, 85 direct jobs and 128 total jobs per year during operations, \$1.4 million direct income and \$2.8 million total income from construction, and \$2.6 million/yr direct income and \$3.3 million/yr total income during operations. The total employment and income created in the ROI for the site would represent a very small change (estimated as less than 0.007%) in projected growth in these indicators of overall regional activity. The total expected in-migration would have only a low impact on regional population growth rates and would require less than 3% of vacant housing stock at the site. No significant impacts on local public finances would be expected.

3.5.2.7 Ecology

Impacts to ecological resources from the continued storage of the additional USEC-generated cylinders would be minimal. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects. (Benchmarks are given in Section C.3.3 of the PEIS.) In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

3.5.2.8 Waste Management

Painting the USEC-generated cylinders at the Paducah site would add a maximum of an additional 8% to the site's total annual LLMW load (added to the 20% projected from painting the DOE-generated cylinders). The continued storage of the USEC-generated cylinders together with the DOE-generated cylinders would thus constitute a moderate potential impact on LLMW management at the Paducah site. The total impact on the projected annual DOE LLMW treatment volume, however, would be negligible to low.

3.5.2.9 Resource Requirements

Although the total resources required would increase by approximately 40% over those presented in Section 3.2.8 as a result of the inclusion of USEC-generated cylinders, continued storage activities would not be resource intensive, and no strategic or critical materials would be

required. Resources required for the continued storage of the DOE- and USEC-generated cylinders would have a negligible to low impact on the local or national availability of materials.

3.5.2.10 Land Use

The cylinder yards that are or would be used to store USEC-generated cylinders have either already been used as cylinder yards or would be located in previously developed areas and thus would not affect land use at the Paducah site under the no action alternative.

3.5.2.11 Cultural Resources

The yards for USEC-generated cylinders at the Paducah site are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for the National Register of Historic Places. Therefore, impacts to cultural resources would not be likely.

3.5.2.12 Environmental Justice

No disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah site in association with the continued storage of the USEC-generated cylinders.

3.5.3 Potential Environmental Impacts from Continued Storage of the Entire Cylinder Inventory (DOE- and USEC-Generated Cylinders) under the Action Alternatives

Under the action alternatives, the inclusion of USEC-generated cylinders would increase the number of cylinders managed by DOE at the Paducah site by 42%. Under the action alternatives, the duration of continued cylinder storage at the Paducah site was assumed to be extended by about 6 years, from 2028 to 2034, to account for the time required to process the additional cylinders. The total time of cylinder storage evaluated was increased from 30 to 36 years (i.e., from 1999 to 2028 to from 1999 to 2034).

3.5.3.1 Human Health and Safety — Normal Operations

3.5.3.1.1 Workers

Under the action alternatives, the continued storage of the additional USEC cylinders was estimated to increase the total dose to involved workers by about 40%, to a total of 640 person-rem. This would result in less than 1 LCF among involved workers (including both DOE- and USEC-generated cylinders) over the assumed 30-year duration of continued cylinder storage. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.)

In general, the average annual radiation dose to individual workers associated with management of the additional USEC cylinders would be the same as that reported in Section 3.4.1.1 for DOE-generated cylinders (i.e., 650 mrem/yr; well within applicable standards) because additional workers would be used instead of having the same individuals conduct extra activities at the site.

Increased exposure to chemicals would not be expected to increase health impacts among involved or noninvolved workers. The total estimated hazard index (when both DOE- and USEC-generated cylinders are considered) would be less than 0.003 for noninvolved workers at the site.

3.5.3.1.2 General Public

The management of USEC-generated cylinders would result in a potential increase in the total radiation dose to the public around the Paducah site from airborne releases. The increase would be proportional to the increase in the total cylinder inventory and number of hypothetical cylinder breaches (i.e., approximately 40%). Therefore, it was estimated that the total radiation dose to the general public within 50 mi (80 km) of the Paducah site would increase by about 0.2 person-rem, resulting in a total dose of 0.7 person-rem over the period 1999 through 2034. This level of exposure would remain well below levels expected to cause any adverse health effects.

The maximum radiation dose to an individual near the Paducah site would also increase because of the additional management of USEC-generated cylinders. However, this increase would be such that the dose to an individual near the site would be less than 1 mrem/yr, well within health standards. Similarly, the change in the potential for noncancer health effects from exposure to airborne uranium and HF releases would be such that the maximum total hazard index for an individual due to continued cylinder storage activities would remain less than 0.1.

Potential short- and long-term health impacts from surface and groundwater contamination associated with the management of the USEC-generated cylinders would be the same as those for DOE-generated cylinders discussed in Section 3.4.1. This result would occur because the modeling

of releases to groundwater at the Paducah site for the DOE-generated cylinders represents a worst-case scenario; additional breaches from USEC cylinders stored in different yards would not increase the estimated groundwater concentrations.

3.5.3.2 Human Health and Safety — Accident Conditions

3.5.3.2.1 Physical Hazards

The total number of worker fatalities and injuries associated with continued storage of the entire inventory under the action alternatives at the Paducah site (including USEC cylinders) would be 0.04 fatality and about 60 injuries.

3.5.3.2.2 Accidents Involving Releases of Radiation or Chemicals

For accident consequences, impacts would be the same as those for the DOE-generated cylinders under the no action alternative discussed in Section 3.4.2. Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC cylinders, this increase would not be expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used for this analysis.

3.5.3.3 Transportation

The continued storage of the USEC-generated cylinders under the action alternatives would result in small additional quantities of LLW and LLMW requiring shipment annually (from cylinder monitoring and maintenance activities). This additional waste would result in less than one additional waste shipment each year. Because of the small number of shipments and the low concentrations of contaminants expected, the potential environmental impacts from these shipments would be negligible.

3.5.3.4 Air Quality

The continued storage of additional USEC cylinders at the Paducah site through the year 2034 would not result in significant impacts to air quality. The estimated concentrations of criteria pollutants from continued storage activities at the site would remain within applicable standards and guidelines. However, because potential PM₁₀ concentrations during construction activities were estimated to be close to the standards, procedures to reduce these emissions might

have to be implemented during actual construction activities. The estimated maximum 24-hour average HF concentration at the Paducah site would increase from about 0.22 : g/m³ to about 1.2 : g/m³. The overall concentration for the Paducah site would still be well below the Kentucky primary 24-hour standard for HF of 800 : g/m³.

3.5.3.5 Water and Soil

Additional water use for continued storage of USEC-generated cylinders at the Paducah site under the action alternatives was roughly estimated to be 0.8 million gal for construction and 67,000 gal/yr for operations. The estimated total water use would be about 3 million gal for construction and 230,000 gal/yr during operations at Paducah.

As discussed in Section 3.5.2.4, the overall impacts to surface water, groundwater, and soil from the continued storage of USEC cylinders would be the same as those estimated for the DOE-generated cylinders in Sections 3.4.4.1 and 3.4.4.2. The estimated maximum groundwater uranium concentrations from continued storage at the Paducah site (i.e., 20 ug/L) would not change as a result of considering the USEC cylinders. Potential groundwater impacts would be mitigated by collecting and treating runoff from the cylinder yards and by identifying and repairing breached cylinders as soon as possible. The estimated maximum soil uranium concentration would remain less than 7 : g/g, well within the 230-: g/g guideline used for comparison.

3.5.3.6 Socioeconomics

Additional construction activities that would result from the addition of USEC-generated cylinders at the Paducah site under the action alternatives would generate approximately 8 additional direct jobs and about 34 additional total jobs. Operational activities at the Paducah site would create 25 additional direct jobs and 38 additional total jobs per year. Direct additional income from construction at the Paducah site in the peak year would be \$0.4 million, and total additional income in the peak year would be \$0.8 million. During operations, additional direct and total income at the Paducah site would be \$0.8 million and \$1 million per year, respectively.

The total socioeconomic impacts from continued cylinder storage at the Paducah site (when both DOE- and USEC-generated cylinders are considered) would be 28 direct jobs and 114 total jobs in the peak construction year, 85 direct jobs and 128 total jobs per year during operations, \$1.4 million direct income and \$2.8 million total income from construction, and \$2.6 million/yr direct income and \$3.2 million/yr total income during operations. The total employment and income created in the ROI for the site would represent a very small change (estimated as less than 0.007%) in projected growth in these indicators of overall regional activity. The total expected in-migration would have only a low impact on regional population growth rates and would require less than 3%

of vacant housing stock at the site. No significant impacts on local public finances would be expected.

3.5.3.7 Ecology

Impacts to ecological resources from continued storage of the total cylinder inventory would be the same as those discussed under the action alternatives for DOE-generated cylinders only: negligible to low (Section 3.4.6). Concentrations of uranium in groundwater and surface water would remain well below benchmark values for toxic and radiological effects (see Section C.3.3 of the PEIS). The maximum estimated soil uranium concentration would be about equal to the benchmark concentration. Construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

3.5.3.8 Waste Management

Continued storage of USEC-generated cylinders under the action alternatives would increase waste impacts at the site. The maximum additional impacts from management of the USEC-generated cylinders at the Paducah site would be the same as those under the no action alternative discussed in Section 3.5.2.8. (The maximum annual LLMW generation amount is not decreased in comparison with the no action alternative, because most of the cylinder painting would occur in the early years of maintenance for both the no action alternative and the action alternatives.) Because the annual treatment volumes would not change, operational impacts related to waste handling would not be affected. The continued storage of the USEC-generated cylinders together with the DOE-generated cylinders would constitute a moderate potential impact on LLMW management at the Paducah site. The total impact on the projected annual DOE LLMW treatment volume, however, would be negligible to low.

3.5.3.9 Resource Requirements

Although the total resources required would increase by approximately 40% over those presented in Section 3.4.8 as a result of the inclusion of USEC-generated cylinders, continued storage activities would not be resource intensive, and no strategic or critical materials would be required. The continued storage of the DOE- and USEC-generated cylinders under the action alternatives would have a negligible to low impact on resource requirements at the Paducah site.

3.5.3.10 Land Use

The cylinder yards that are or would be used to store USEC-generated cylinders have either already been used as cylinder yards or would be located in previously developed areas and thus would not affect land use at the Paducah site under the action alternatives.

3.5.3.11 Cultural Resources

The yards for USEC-generated cylinders at the Paducah site are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for the National Register of Historic Places. Therefore, impacts to cultural resources would not be likely.

3.5.2.12 Environmental Justice

No disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah site in association with the continued storage of the USEC-generated cylinders under the action alternatives.

4 ENVIRONMENTAL IMPACTS OF OPTIONS FOR PREPARING CYLINDERS FOR SHIPMENT OR LONG-TERM STORAGE AT THE PADUCAH SITE

The term “cylinder preparation” refers to the activities necessary to prepare depleted UF₆ cylinders for off-site transportation. In this report, transportation of depleted UF₆ cylinders is assumed to be required from the Paducah site to either a conversion facility or a long-term storage site (for long-term storage of UF₆). UF₆ cylinders have been transported safely by truck and rail between DOE facilities, electric utilities, reactor fuel fabricators, and research nuclear reactors for about 40 years.

Depleted UF₆ cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. The DOT requirements, specified in Title 49 of the CFR, are intended to maintain the safety of shipments during both routine and accident conditions. Cylinders meeting the DOT requirements could be loaded directly onto specially designed truck trailers or railcars for shipment. However, after several decades in storage, some cylinders no longer meet the DOT requirements. Two cylinder preparation options, which address different approaches that could be used to transport the depleted UF₆ stored in these cylinders, are considered in this report. These two options, discussed in detail in Section 4.2, are a cylinder overcontainer option and a cylinder transfer option.

Cylinder Preparation Options

Cylinder preparation refers to the activities necessary to prepare depleted UF₆ cylinders for off-site transportation. Depleted UF₆ cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. However, after several decades in storage, some cylinders no longer meet these requirements. Two options for preparing these cylinders for shipment are considered in the PEIS.

Cylinder Overcontainers. Cylinders that do not meet DOT requirements could be placed inside protective metal “overcontainers” for shipment. These reusable overcontainers, which would be slightly larger than a cylinder, would be designed to meet all DOT requirements.

Cylinder Transfer. In this option, the depleted UF₆ in cylinders that do not meet DOT requirements would be transferred to new cylinders capable of being transported.

Note: For both options, cylinders that meet DOT shipment requirements would be shipped directly.

It is unknown exactly how many of the depleted UF₆ cylinders currently do not meet the DOT transportation requirements. The potential problems with cylinders are related to three DOT requirements that must be satisfied before shipment: (1) cylinders must be filled to less than 62% of the maximum capacity (the fill-limit was reduced to 62% from 64% around 1987); (2) the pressure within cylinders must be less than atmospheric pressure; and (3) cylinders must be free of damage or defects, such as dents, and have a specified minimum wall thickness. Cylinders not meeting these requirements are referred to as overfilled, overpressurized, and substandard, respectively. Some cylinders may fail to meet more than one requirement.

The assessment of cylinder preparation options considers the environmental impacts of preparing the entire DOE-generated depleted UF₆ cylinder inventory at the Paducah site for shipment over a 20-year period. Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment. If a cylinder failed the inspection, it would be prepared by using one of the two cylinder preparation options (see Section 4.2).

The estimated number of cylinders not meeting DOT requirements at the Paducah site would range from 9,600 to 28,351 (the entire Paducah inventory of DOE-generated cylinders). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 480 to 1,420 cylinders annually and, conversely, to prepare from 0 to 940 standard cylinders per year for shipment.

The environmental impacts from the cylinder preparation options were evaluated on the basis of information provided in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL] 1997), i.e., preconceptual design data for each option, including descriptions of facility layouts; resource requirements; estimated effluents, wastes, and emissions; and potential accident scenarios. In the engineering analysis report, estimates for cylinder transfer operations ranged in capacity from 320 to 1,600 cylinders processed per year; whereas overcontainer and standard cylinder operations were addressed on a site-specific basis for a reference case for each site (i.e., 960 cylinders/yr with overcontainers for the Paducah site) with some information provided on scaling up or down from the reference case (LLNL 1997). Supporting data for the overcontainer and transfer facility analyses were derived by Folga (1996b) by using information provided in the engineering analysis report (LLNL 1997).

For assessment purposes, it was assumed that all cylinders would require transportation. However, the actual need for transportation of cylinders would depend on site selection and other considerations to be addressed in the second tier of the NEPA process.

4.1 SUMMARY OF CYLINDER PREPARATION OPTION IMPACTS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options at the Paducah site. Additional discussion and details related to the assessment methodologies and results for individual areas of impact are provided in Section 4.3. After the draft PEIS was completed, management responsibility for approximately 8,600 additional cylinders of depleted UF₆ at the Paducah site was transferred from USEC to DOE. To provide a bounding analysis of environmental impacts, the final PEIS evaluated the environmental impacts of managing an additional 12,000 cylinders at the Paducah site. The impacts associated with preparation of the total cylinder inventory for shipment (including USEC-generated cylinders) are

summarized in Section 4.4. A summary of the estimated environmental impacts associated with preparation of the DOE-generated cylinders only and the total cylinder inventory (DOE-generated plus USEC-generated) is presented in Table 4.1. Ranges of impacts are presented for the over-container option, the cylinder transfer option, and the preparation of standard cylinders (which is required for either option). On the basis of information in Table 4.1 and Sections 4.3 and 4.4, the following general conclusions may be drawn:

- For the cylinder overcontainer option and preparation of standard cylinders, impacts during normal operations would be small and limited to involved workers. No impacts to the off-site public or the environment would occur because no releases would be expected and no construction activities would be required.
- For the cylinder transfer option, impacts during construction and normal operations would generally be small and limited primarily to involved workers. Some small off-site releases of hazardous and nonhazardous materials would occur, although these would have negligible impacts on the off-site public and environment. Construction activities could temporarily impact air quality, but concentrations of criteria pollutants would all be within standards.
- For all cylinder preparation options, there is a potential for low-probability accidents (UF_6 cylinders engulfed in a fire) that could have large consequences. The accident impacts would be limited primarily to workers, but off-site impacts are possible.

4.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the cylinder preparation options considered in the assessment of impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report includes much more detailed information, including descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and descriptions of potential accident scenarios.

Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment.

TABLE 4.1 Summary of Cylinder Preparation Impacts for the Paducah Site^a

Impacts from Preparation of Problem Cylinders ^b		Impacts from Preparation of Standard Cylinders ^c
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Normal Operations: Radiological		
Involved Workers:	Involved Workers:	Involved Workers:
Total collective dose:	Total collective dose:	Total collective dose:
170 – 520 person-rem [250 – 740 person-rem]	600 – 1,000 person-rem [850 – 1,500 person-rem]	0 – 220 person-rem [0 – 310 person-rem]
Total number of LCFs:	Total number of LCFs:	Total number of LCFs:
0.07 – 0.2 LCF [0.1 – 0.3 LCF]	0.2 – 0.4 LCF [0.3 – 0.6 LCF]	0 – 0.09 LCF [0 – 0.12 LCF]
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
No impacts	Annual dose to MEI: 1.9×10^{-6} – 4.9×10^{-6} rem/yr	No impacts
General Public:	General Public:	General Public:
No impacts	Annual cancer risk to MEI: 8×10^{-13} – 2×10^{-12} per year	No impacts
	Total collective dose: 5.1×10^{-5} – 1.3×10^{-4} person-rem [7.2×10^{-5} – 1.8×10^{-4} person-rem]	
	Total number of LCFs: 2×10^{-8} – 5×10^{-8} LCF 3×10^{-8} – 7×10^{-8} LCF]	
	General Public:	
	Annual dose to MEI: 6.8×10^{-6} – 1.7×10^{-5} mrem/yr	
	Annual cancer risk to MEI: 3×10^{-12} – 9×10^{-12} per year	
	Total collective dose to population within 50 miles: 1.1×10^{-3} – 2.9×10^{-3} person-rem [1.6×10^{-3} – 4.1×10^{-3} person-rem]	
	Total number of LCFs in population within 50 miles: 6×10^{-7} – 1×10^{-6} LCF [8×10^{-7} – 2×10^{-6} LCF]	
Human Health – Normal Operations: Chemical		
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
No impacts	No impacts	No impacts
General Public:	General Public:	General Public:
No impacts	No impacts	No impacts

TABLE 4.1 (Cont.)

Impacts from Preparation of Problem Cylinders ^b			Impacts from Preparation of Standard Cylinders ^c
Cylinder Overcontainer Operations	Cylinder Transfer Operations		
Human Health – Accidents: Radiological			
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years		Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem		Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem
Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}		Risk of LCF to MEI: 8×10^{-6}
Collective dose: 15 person-rem	Collective dose: 15 person-rem		Collective dose: 15 person-rem
Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}		Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem		General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem
Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}		Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 28 person-rem	Collective dose to population within 50 miles: 28 person-rem		Collective dose to population within 50 miles: 28 person-rem
Number of LCFs in population within 50 miles: 0.01 LCF	Number of LCFs in population within 50 miles: 0.01 LCF		Number of LCFs in population within 50 miles: 0.01 LCF
Human Health – Accidents: Chemical			
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years		Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):		Noninvolved Workers: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 910 persons	Number of persons with potential for adverse effects: 910 persons		Number of persons with potential for adverse effects: 910 persons
Number of persons with potential for irreversible adverse effects: 300 persons	Number of persons with potential for irreversible adverse effects: 300 persons		Number of persons with potential for irreversible adverse effects: 300 persons
General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):		General Public: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1,900 persons	Number of persons with potential for adverse effects: 1,900 persons		Number of persons with potential for adverse effects: 1,900 persons
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 1 person		Number of persons with potential for irreversible adverse effects: 1 person

TABLE 4.1 (Cont.)

Impacts from Preparation of Problem Cylinders ^b		Impacts from Preparation of Standard Cylinders ^c
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
<i>Human Health — Accidents: Physical Hazards</i>		
Operations: All Workers: 0.029 – 0.087 [0.04 – 0.12] fatality, approximately 39 – 115 [55 – 160] injuries	Construction and Operations: All Workers: 0.31 – 0.34 [0.44 – 0.48] fatality, approximately 210 – 250 [300 – 360] injuries	Operations: All Workers: 0 – 0.043 [0 – 0.061] fatality, approximately 0 – 87 [0 – 124] injuries
<i>Air Quality</i>		
Construction: Not applicable	Construction: 24-hour PM ₁₀ impacts potentially as large as 62% of standard. Concentrations of other criteria pollutants all below 15% of respective standards.	Construction: Not applicable
Operations: Concentrations of all criteria pollutants below 0.08% of respective standards.	Operations: Concentrations of all criteria pollutants below 0.08% of respective standards.	Operations: Concentrations of all criteria pollutants below 0.03% of respective standards.
<i>Water</i>		
Construction: Not applicable	Construction: Negligible impacts to surface water and groundwater	Construction: Not applicable
Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards
<i>Soil</i>		
Construction: Not applicable	Construction: Negligible, but temporary, impacts	Construction: Not applicable
Operations: No impacts	Operations: No impacts	Operations: No impacts
<i>Socioeconomics^d</i>		
Jobs: <5 peak year, preoperations, 120 per year over 20 years, operations [over 26 years, operations]	Jobs: 260 peak year, construction, 200 per year over 20 years, operations [over 26 years, operations]	Jobs: <5 peak year, preoperations, 60 per year over 20 years, operations [over 26 years, operations]
Income: \$0.1 million peak year, preoperations, \$8 million per year over 20 years, operations [over 26 years, operations]	Income: \$12 million peak year, construction, \$10 million per year over 20 years, operations [over 26 years, operations]	Income: \$0.1 million peak year, preoperations, \$4 million per year over 20 years, operations [over 26 years, operations]
Preoperations and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	Construction & Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	Preoperations & Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.

TABLE 4.1 (Cont.)

Impacts from Preparation of Problem Cylinders ^b			Impacts from Preparation of Standard Cylinders ^c
Cylinder Overcontainer Operations	Cylinder Transfer Operations		
<i>Ecology</i>			
Construction: Not applicable	Construction: Potentially moderate impacts to vegetation, wildlife, and wetlands	Construction: Not applicable	
Operations: Negligible impacts	Operations: Negligible impacts	Operations: No impacts	
<i>Waste Management</i>			
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	
<i>Resource Requirements</i>			
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	
<i>Land Use</i>			
No impacts	Use of approximately 21 acres; negligible impacts	No impacts	
<i>Cultural Resources</i>			
Construction: No impacts	Construction: Cannot be determined	Construction: No impacts	
Operations: No impacts	Operations: No impacts	Operations: No impacts	

^a In general, the overall environmental consequences from managing the total cylinder inventory (total of USEC-generated and DOE-generated cylinders) are the same as those from managing the DOE-generated cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE cylinders only. LCF = latent cancer fatality, MEI = maximally exposed individual, PM₁₀ = particulate matter with a mean diameter of 10 : m or less, ROI = region of influence.

^b Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) overpressurized, or (3) damaged or substandard with respect to wall thickness.

^c These impacts must be added to those for either of the two options for preparation of problem cylinders.

^d For construction, direct jobs and direct income are reported for the peak construction year. For operations, direct jobs and income are presented as annual averages. See Section 4.3.5 for details on indirect impacts in the Paducah site ROI.

The preparation of standard cylinders for shipment (cylinders that meet DOT requirements) would include inspection activities, unstacking, on-site transfer, and loading onto a truck trailer or railcar. The cylinders would be secured using the appropriate tiedowns, and the shipment would be labeled in accordance with DOT requirements. Handling and support equipment and procedures for on-site movement and loading the cylinders would be of the same type currently used for cylinder management activities at the three storage sites.

4.2.1 Cylinder Overcontainers

Cylinder overcontainers are one option for transporting cylinders that do not meet DOT requirements. An overcontainer is simply a container into which a cylinder would be placed for shipment. The metal overcontainer would be designed, tested, and certified to meet all DOT shipping requirements. The overcontainer would be suitable to contain, transport, and store the cylinder contents regardless of cylinder condition. In addition, the overcontainers could be designed as pressure vessels, enabling the withdrawal of the depleted UF₆ from the cylinder in an autoclave (a device used to heat cylinders using hot air).

The type of overcontainer evaluated in the PEIS, shown in Figure 4.1, is a horizontal “clamshell” vessel (LLNL 1997). For transportation, a cylinder not meeting DOT requirements would be placed into an overcontainer already on a truck trailer or railcar. The overcontainer would be closed, secured, and the shipment would be labeled in accordance with DOT requirements. The handling and support equipment for on-site movement and loading the cylinder into the overcontainer would be of the same type currently used for cylinder management activities at the three DOE sites. The overcontainers could be reused following shipment. The overcontainer option would not require the construction of new facilities.

4.2.2 Cylinder Transfer

A second option for transporting cylinders that do not meet DOT requirements would be to transfer the depleted UF₆ from substandard cylinders to new cylinders that meet all DOT requirements. This option would require the construction of a new facility. A representative transfer facility is shown in Figure 4.2. The transfer facility would be a stand-alone facility capable of receiving cylinders, storing a small number of cylinders, and transferring the contents to new cylinders. The transfer of depleted UF₆ would take place in a process building by placing substandard cylinders into autoclaves. The autoclaves would be used to heat the contents of the cylinder (using hot air), forming UF₆ gas which then would be piped to a new cylinder. The new cylinders could be shipped by placing them directly on appropriate trucks or railcars. The empty cylinders would be cleaned and treated with other scrap metals. (See Section 5 for details on the treatment of empty cylinders.)

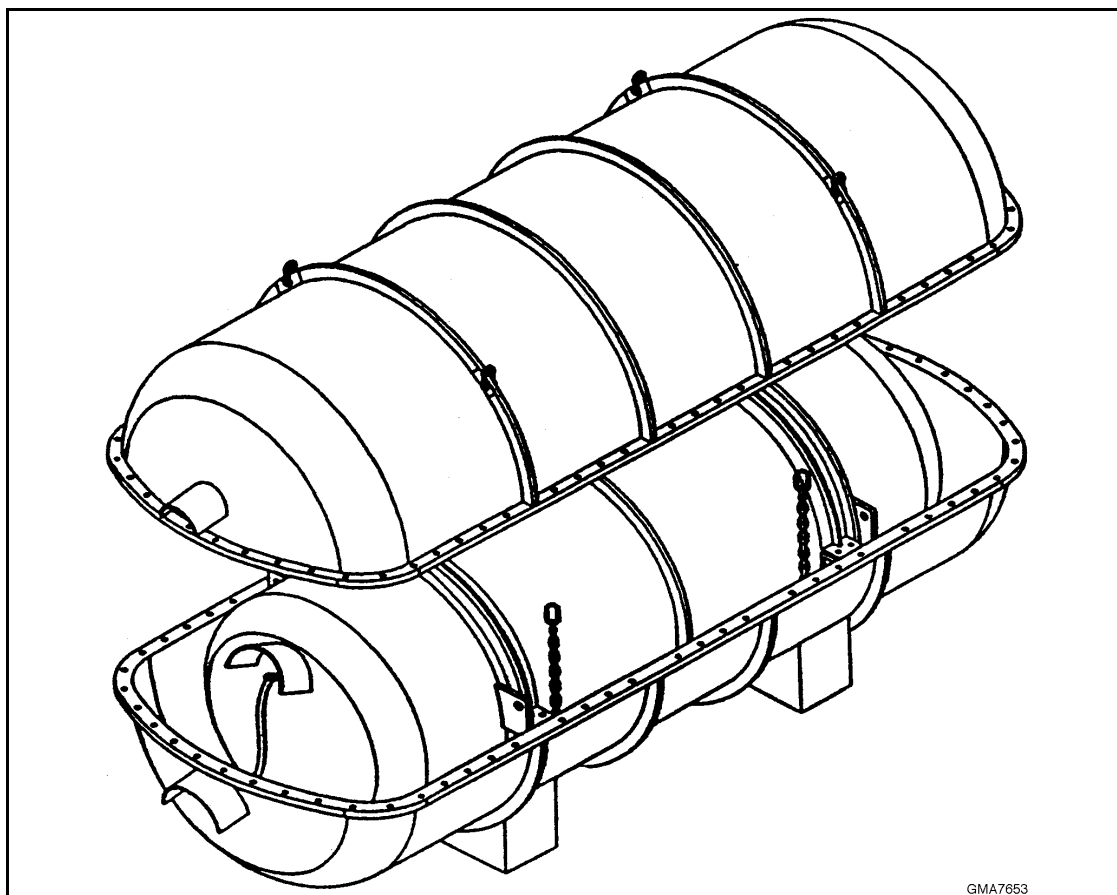


FIGURE 4.1 Horizontal “Clamshell” Overcontainer for Transportation of Cylinders Not Meeting DOT Requirements (Source: LLNL 1997)

4.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options, including impacts from construction (of a cylinder transfer facility), and during operations. Information related to the assessment methodologies for each area of impact is provided in Appendix C of the PEIS.

The environmental impacts from the cylinder preparation options were evaluated on the basis of the information described in the engineering analysis report (LLNL 1997) and in Folga (1996a). The following general assumptions apply to the assessment of impacts:

- The assessment considers preparation of cylinders that meet DOT requirements (standard cylinders), as well as those cylinders that do not meet the requirements.

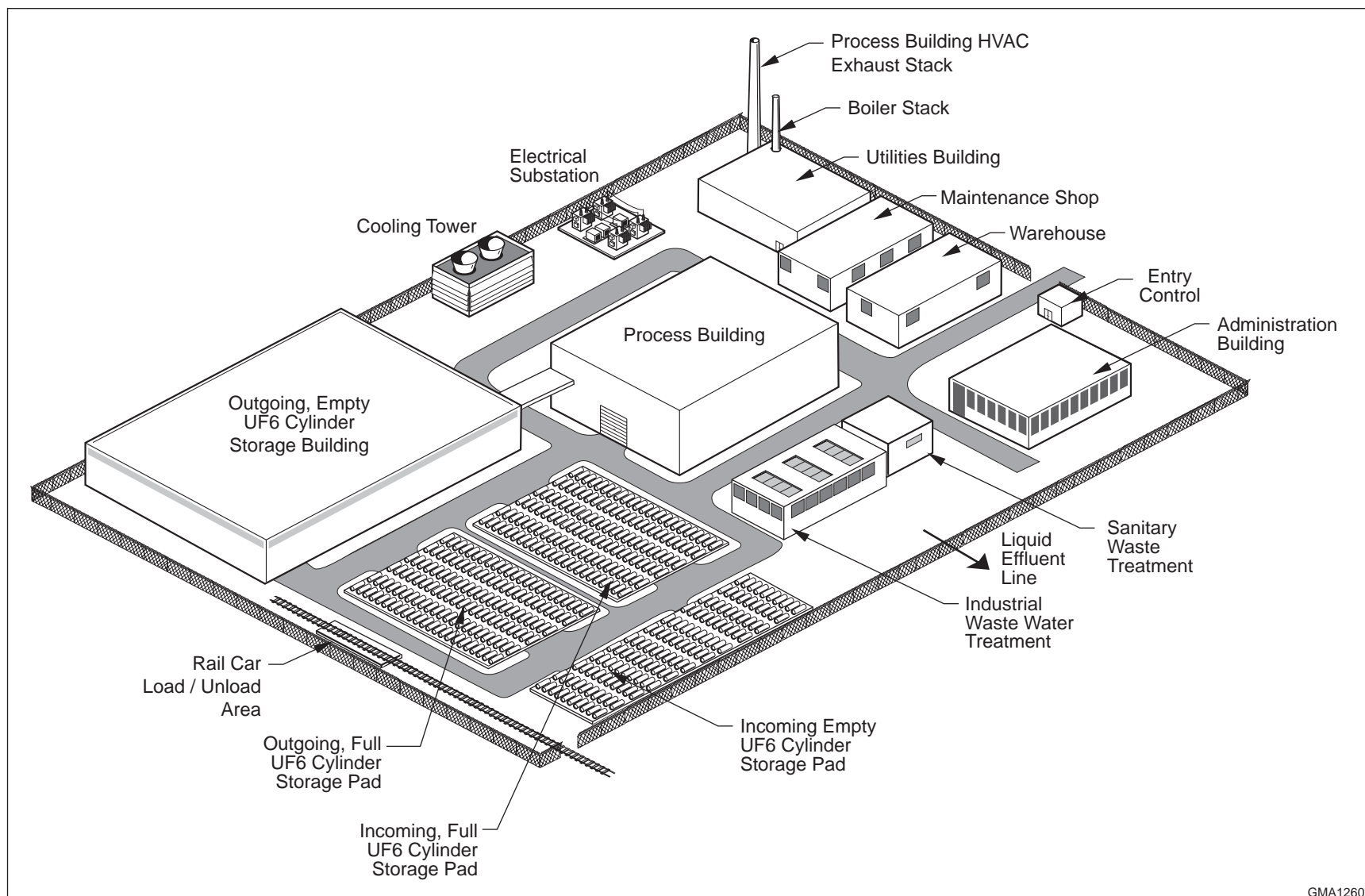


FIGURE 4.2 Representative Layout of a Transfer Facility Site (Source: LLNL 1997)

- Evaluation of standard cylinder preparation and the cylinder overcontainer option includes only an operational phase — no construction activities would be required. Additionally, these options would not generate emissions of uranium compounds or HF during normal operations.
- The evaluation of the cylinder transfer option includes construction of a facility in addition to operations. The operation of a cylinder transfer facility would involve small releases of uranium compounds and HF as air and water effluents during normal operations.
- Impacts were evaluated by assuming a range in annual processing requirements, because the actual number of cylinders that would not meet DOT requirements at the time of shipment could not be determined. The ranges of problem cylinders are discussed in the introduction to Section 4. The remaining cylinders were assumed to be standard cylinders that could be shipped directly.
- Cylinder preparation activities would take place over a 20-year period, from 2009 through 2028, for all alternatives except the no action alternative, which does not involve cylinder preparation. (When USEC cylinders are considered, activities are assumed to extend about an additional 6 years through 2034; see Section 4.4.)

4.3.1 Human Health — Normal Operations

4.3.1.1 Radiological Impacts

Potential radiological impacts for the cylinder preparation options were assessed for involved workers, noninvolved workers, and the general public. Detailed discussions of the methodologies used in the radiological impact analyses are provided in Appendix C of the PEIS and Cheng et al. (1997).

Impacts to involved workers would result primarily from external radiation and would depend only on the number of cylinders handled. The estimated collective doses to involved workers are presented in Figures 4.3, 4.4, and 4.5 for the overcontainer option, cylinder transfer option, and preparation of standard cylinders, respectively. Because no airborne or waterborne releases of uranium would be generated for the overcontainer option and preparation of standard cylinders, no radiological impacts would be expected to noninvolved workers or members of the general public. Impacts to these two receptors for the cylinder transfer option are presented in Figures 4.6 through 4.9. The ranges of impacts are due to the range in assumed numbers of cylinders handled annually.

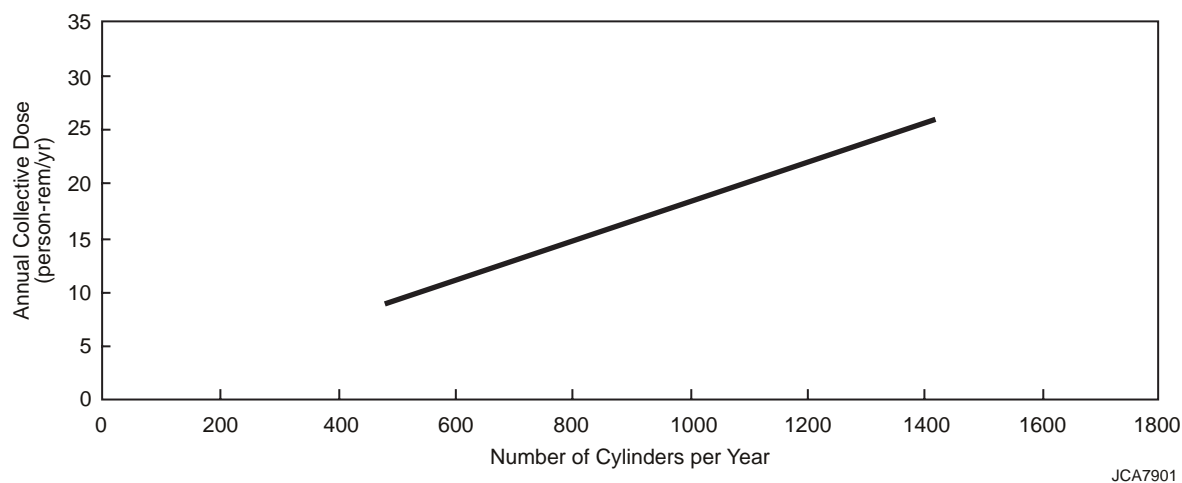


FIGURE 4.3 Annual Collective Dose to Involved Workers at the Paducah Site from Preparing Problem Cylinders for Shipment Using Overcontainers

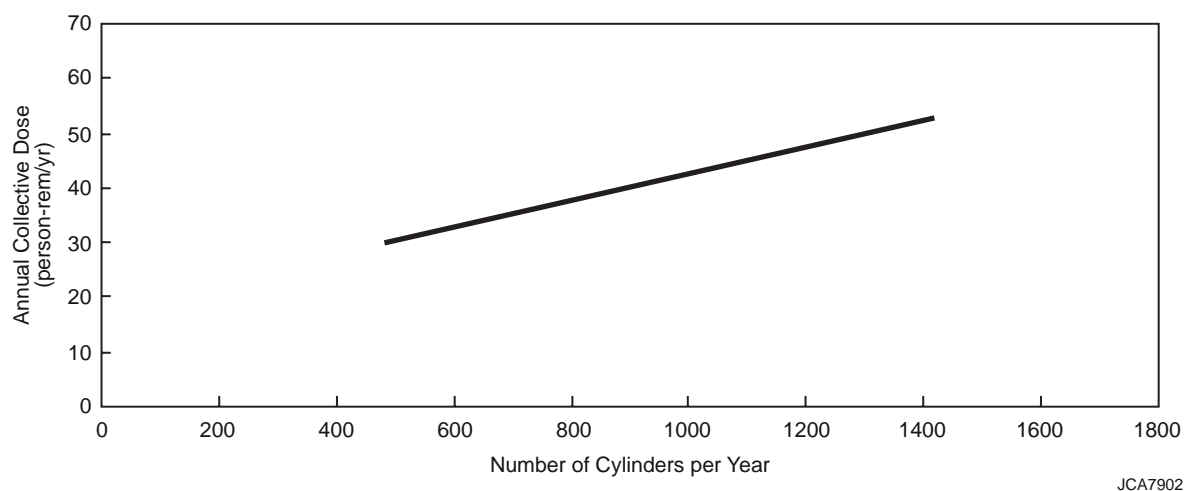


FIGURE 4.4 Estimated Annual Collective Dose to Involved Workers at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

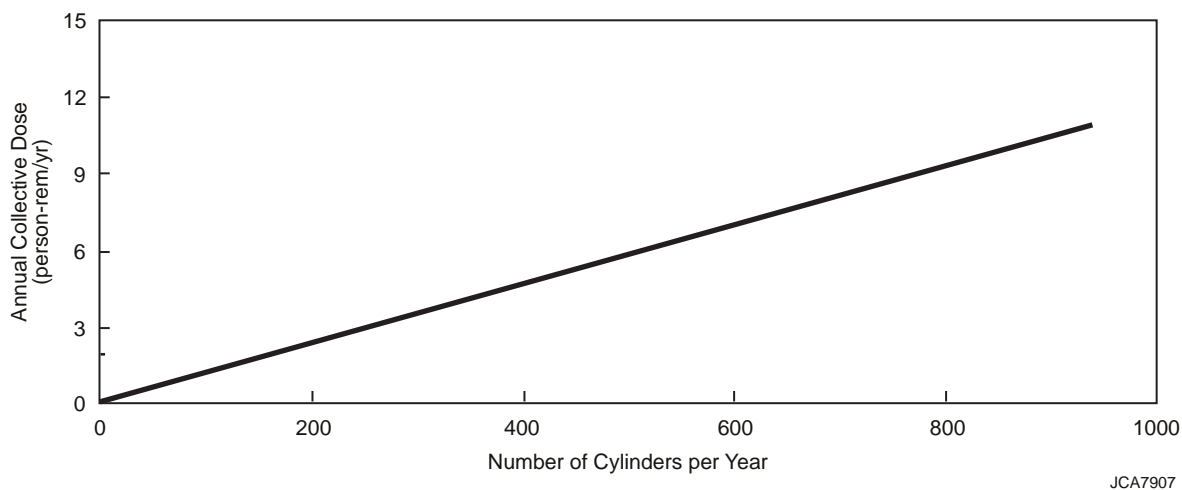


FIGURE 4.5 Annual Collective Dose to Involved Workers at the Paducah Site from Preparing Standard Cylinders for Shipment

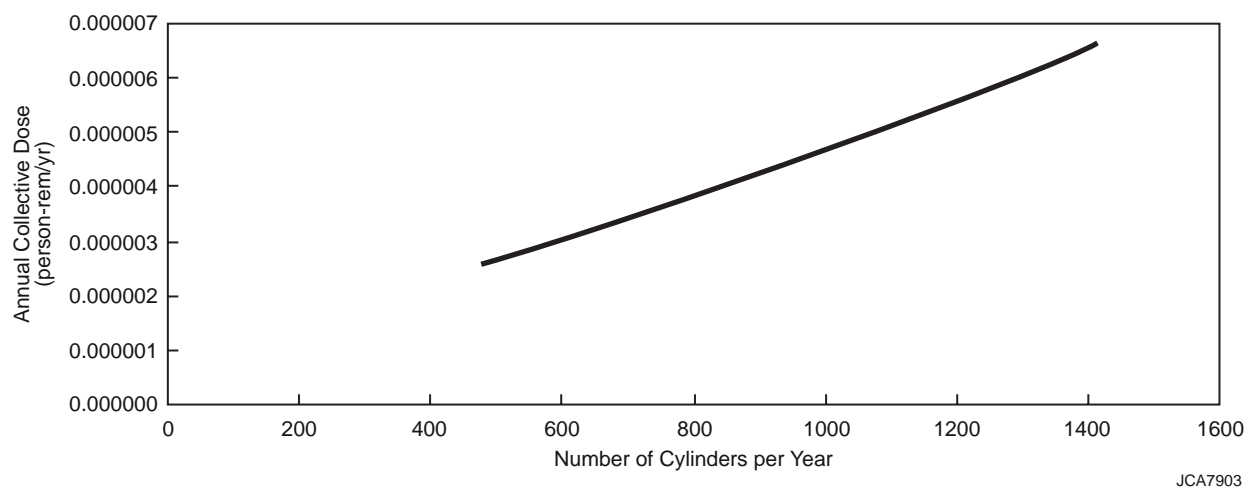


FIGURE 4.6 Estimated Annual Collective Dose to Noninvolved Workers at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (population size of noninvolved workers about 2,000 at the Paducah site)

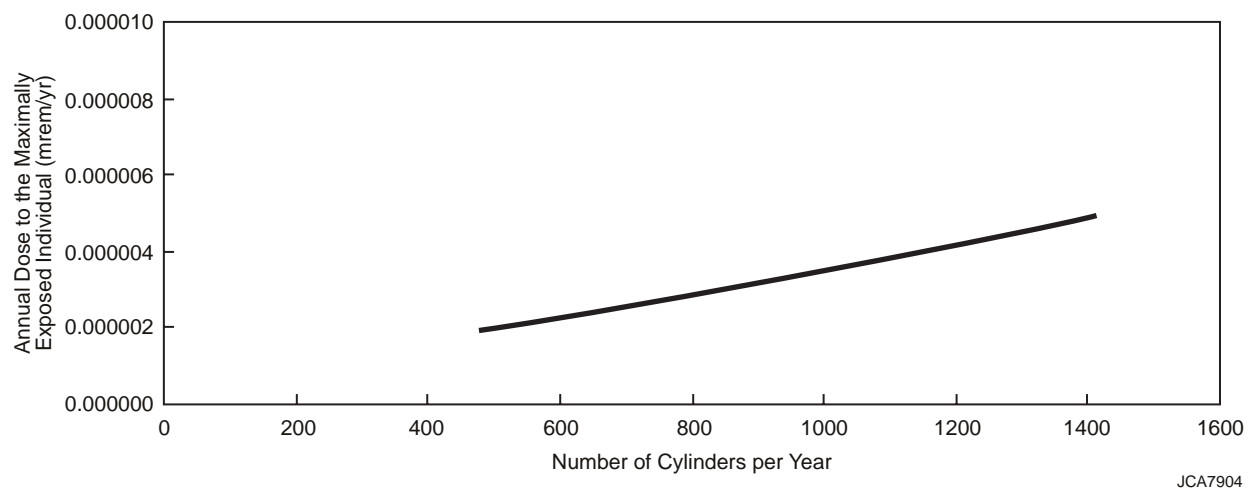


FIGURE 4.7 Estimated Annual Dose to the Noninvolved Worker MEI at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

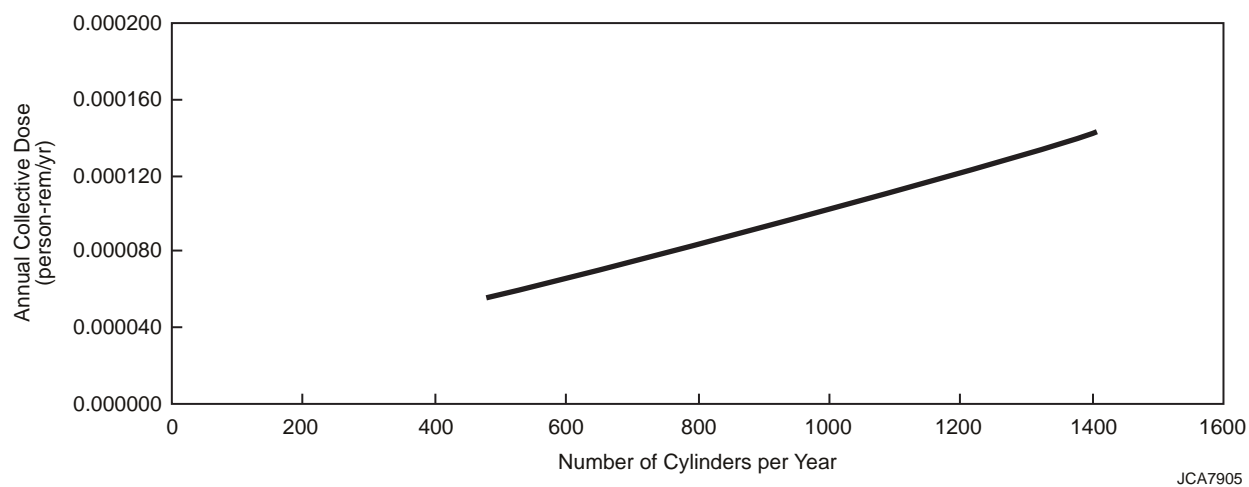


FIGURE 4.8 Estimated Annual Collective Dose to the General Public at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposure to airborne emissions; population size of general public about 500,000 at the Paducah site)

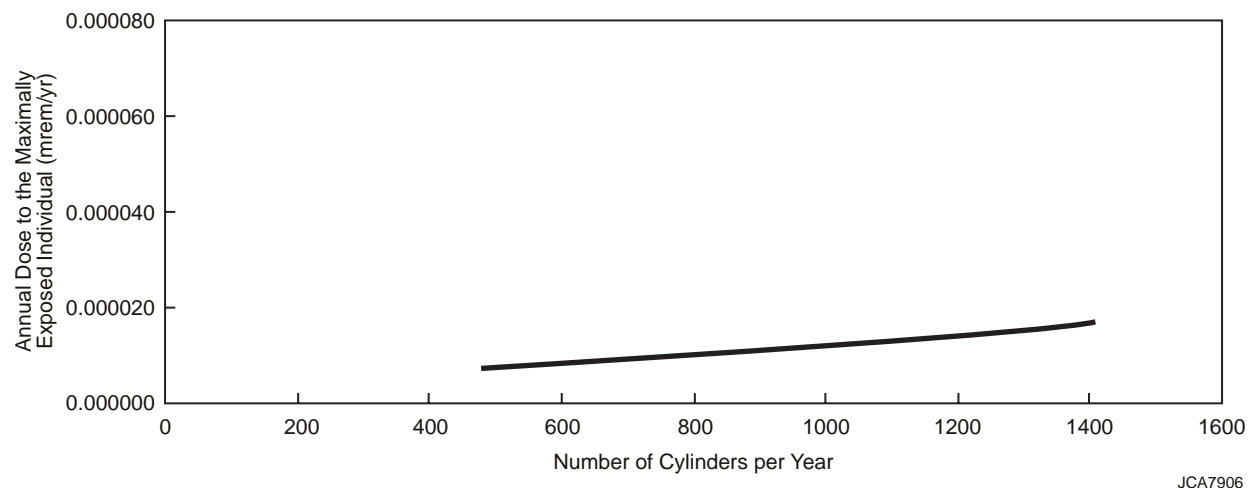


FIGURE 4.9 Estimated Annual Dose to the General Public MEI at the Paducah Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposures would result from airborne emissions and discharge of wastewater)

In general, impacts for the overcontainer option would be less than those for the cylinder transfer option. The average doses to involved workers for all cylinder preparation activities would be less than 660 mrem/yr, which is less than the regulatory limit of 5,000 mrem/yr (10 CFR Part 835). Exposure of noninvolved workers and members of the general public would be extremely small, less than 3.0×10^{-5} mrem/yr.

4.3.1.1.1 Overcontainer Option

Potential external radiation exposures of involved workers would occur from preshipment inspection, testing, and surveying of cylinders; unstacking and retrieving cylinders; on-site transportation of cylinders by straddle buggy; loading cylinders into overcontainers placed on trucks or railcars; and packaging cylinders. The annual collective dose to involved workers was estimated to be approximately 8.7 to 26 person-rem/yr for about 16 to 47 workers at the Paducah site. Assuming that the workers would work 5 hours per day with an availability factor of 75%, i.e., 3.75 hours per day for cylinder preparation activities (Folga 1996c), the average individual involved worker dose would be approximately 540 mrem/yr. The corresponding average cancer risk would be approximately 0.0002 per year (i.e., an individual's chance of developing a latent fatal cancer would be less than 1 in 5,000 per year).

4.3.1.1.2 Cylinder Transfer Option

The collective dose to involved workers would range from 30 to 52 person-rem/yr for approximately 52 to 94 workers at the Paducah site. The average individual dose to involved workers would be less than 660 mrem/yr, corresponding to an LCF risk of 3×10^{-4} per year (one chance in 3,300 per year).

Radiation doses to noninvolved workers vary depending on the processing rate of cylinders, site-specific meteorological conditions, and distribution and population of the on-site workers (for collective doses). The estimated radiation dose to the MEI would be extremely small, less than 8×10^{-6} mrem/yr, due to the small airborne emission rates of uranium. Impacts to the off-site public would also depend on the factors discussed for noninvolved workers, but instead of the distribution and population of the on-site workers, the impacts would be determined by the distribution and population of the off-site public (for collective dose).

The radiation dose to the MEI of the off-site public would be greater than that for the MEI of the noninvolved workers because of the assumed additional exposure from drinking surface water. The radiation dose from drinking surface water would be greater than that from airborne emissions. The radiation doses to the off-site public MEI from normal operations of the cylinder transfer facility were estimated to be less than 2×10^{-5} mrem/yr, which is extremely small compared with the regulatory limit of 100 mrem/yr.

4.3.1.1.3 Preparation of Standard Cylinders

At the Paducah site, the collective radiation doses to involved workers were estimated to range from 0 to 11 person-rem/yr. The lower range results from the assumption that all the cylinders at the site would be problem cylinders. A maximum of 18 workers would be required for the preparation activities. The average individual dose to involved workers was estimated to be less than 600 mrem/yr.

4.3.1.2 Chemical Impacts

The only potential chemical impacts that could be associated with cylinder preparation options would be from exposure to emissions from a cylinder transfer facility; no impacts during normal operations would be expected for the cylinder overcontainer option or preparation of standard cylinders because no releases would occur. Risks from normal operations were quantified on the basis of calculated hazard indices. Information on the exposure assumptions, health effects assumptions, reference doses, and calculational methods used in the chemical impact analysis is provided in Appendix C of the PEIS and Cheng et al. (1997).

During cylinder transfer operations, very small quantities of UO_2F_2 effluent would be discharged into the air and surface water. Estimates of the hazardous chemical human health impacts resulting from cylinder transfer operations were calculated for the range of cylinders that might require processing at the Paducah site (i.e., up to 1,420 annually). Inhalation of HF was not included in the hazard index calculations because HF emissions from the cylinder transfer facility would be hundreds of times lower than HF emissions from conversion facilities (see Chapter 5), for which no chemical impacts were predicted.

No impacts to noninvolved workers or the general public would be expected from normal transfer facility operations. The maximum (high case) hazard index for chemical impacts to the noninvolved worker MEI working at the cylinder transfer facility would be less than or equal to 3.2×10^{-8} at the Paducah site. This value is considerably below the threshold for adverse effects (i.e., the ratio of intake to reference dose is much less than 1). The maximum (high case) hazard index for chemical impacts to the general public MEI would be less than or equal to 2.8×10^{-6} ; this value is also considerably below the threshold for adverse effects.

4.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table 4.2. The results for the radiological and chemical health impacts of the maximum-consequence accident in each frequency category are presented in Sections 4.2.1 and 4.2.2. The bounding accidents are the same for both the cylinder overcontainer option and the cylinder transfer option. Results for all accidents listed in Table 4.2 are presented in Policastro et al. (1997). Detailed descriptions of the methodology and assumptions used in these calculations are also provided in Appendix C of the PEIS and Policastro et al. (1997).

4.3.2.1 Radiological Impacts

Table 4.3 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table 4.4. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions were considered for each cylinder preparation option (see Appendix C of the PEIS). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.
- The maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 0.077 rem. This dose is less than the 25-rem dose recommended by the NRC (1994) for assessing the adequacy of protection of public health and safety from potential accidents.
- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table 4.4] by the

TABLE 4.2 Accidents Considered for the Cylinder Preparation Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Cylinder Overcontainers					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the dry ground.	UF ₆	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 time in 1 million years)					
Small plane crash, two full 48G cylinders ^b	A small plane crash affects two full 48G UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	4,240 1,190	0 to 30 30 to 121	Ground
Cylinder Transfer					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the dry ground.	UF ₆	24	60 (continuous)	Ground
Cylinder valve shear	A single UF ₆ cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF ₆ from the valve onto the ground.	UF ₆	0.25	120 (continuous)	Ground
UF ₆ vapor leak	A UF ₆ transfer line leaks 5% of its flowing contents for 10 minutes due to potential compressor or pipe leakage.	UO ₂ F ₂ HF	0.009 2.4	30	Stack
UF ₆ liquid leak	A drain line from the UF ₆ condensers leaks 5% of its flowing contents due to potential condenser or pipe leakage.	UO ₂ F ₂ HF	0.0045 1.2	30	Stack
Loss of off-site electrical power	Off-site power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
Loss of cooling water	Cooling water flow to the UF ₆ condenser is lost, and UF ₆ vapor is released.	UO ₂ F ₂ HF	0.009 2.4	2	Stack

TABLE 4.2 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Cylinder Transfer (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the wet ground.	HF	96	60 (continuous)	Ground
UF ₆ cold trap rupture	A UF ₆ cold trap is overfilled with UF ₆ and ruptures during heating, releasing UF ₆ into the process building.	UO ₂ F ₂ HF	0.13 34	30	Stack
Extremely Unlikely Accidents (frequency: from 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Earthquake	A UF ₆ compressor discharge pipe is cleanly sheared during a design-basis earthquake and leaks for 1 minute.	UO ₂ F ₂ HF	0.018 4.7	30	Stack
Tornado	A design-basis tornado does not result in significant releases because UF ₆ is a solid at ambient conditions.	No release	NA	NA	NA
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude flooding.	No release	NA	NA	NA
Small plane crash, two full 48G cylinders	A small plane crash affects two full 48G UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	4,240 1,192	0 to 30 30 to 121.4	Ground

^a Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

TABLE 4.3 Estimated Radiological Doses per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site

Accident ^a	Frequency ^b Category	Maximum Dose ^c				Minimum Dose ^c			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.4	2.3×10^{-3}	2.6×10^{-1}	3.3×10^{-3}	6.3×10^{-2}	9.8×10^{-5}	3.0×10^{-2}
UF ₆ cold trap rupture ^d	U	1.0×10^{-7}	1.5×10^{-4}	1.1×10^{-7}	5.6×10^{-4}	2.1×10^{-8}	2.8×10^{-5}	8.6×10^{-8}	2.3×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.5×10^1	1.5×10^{-2}	2.8×10^1	3.7×10^{-3}	1.3	1.9×10^{-3}	1.1
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	4.9	4.9×10^{-3}	3.7×10^{-1}	8.7×10^{-4}	6.4×10^{-1}	6.2×10^{-4}	5.2×10^{-2}

^a The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^b Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^c Maximum and minimum doses reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

^d Applicable only to the cylinder transfer option.

TABLE 4.4 Estimated Radiological Health Risks per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site^a

Accident ^b	Frequency Category ^c	Maximum Risk ^d (LCFs)				Minimum Risk ^d (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Corroded cylinder spill, dry conditions	L	3×10^{-5}	6×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	3×10^{-5}	5×10^{-8}	1×10^{-5}
UF ₆ cold trap rupture ^e	U	4×10^{-11}	6×10^{-8}	4×10^{-11}	3×10^{-7}	8×10^{-12}	1×10^{-8}	4×10^{-11}	1×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	1×10^{-2}	1×10^{-6}	5×10^{-4}	1×10^{-6}	5×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	2×10^{-4}	3×10^{-7}	3×10^{-4}	3×10^{-7}	3×10^{-5}

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.0001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum risks reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

^e Applicable only to the cylinder transfer option.

annual probability of occurrence by the number of years of operation) would be less than 1 for all of the accidents.

4.3.2.2 Chemical Impacts

The accidents considered for the cylinder preparation options are listed in Table 4.2. The results of the accident consequence modeling for chemical impacts are given in Tables 4.5 and 4.6. The results are presented as the (1) number of persons with potential for adverse effects and (2) the number of persons with potential for irreversible adverse effects. The results are given for the accident within each accident frequency category that would affect the largest number of persons (total of workers and off-site population) (Policastro et al. 1997). The impacts presented here are based on the assumption that the accidents would occur. The accidents listed in Tables 4.5 and 4.6 are not identical because an accident with the largest impacts for adverse effects might not lead to the largest impacts for irreversible adverse effects. The following general conclusions may be drawn from the chemical accident assessment:

- If the accidents identified in Tables 4.5 and 4.6 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 1,900 (maximum corresponding to the vehicle-induced fire scenario), and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 1 (maximum corresponding to the corroded cylinder spill with pooling scenario).
- If the accidents identified in Tables 4.5 and 4.6 did occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 910 (maximum corresponding to the vehicle-induced fire scenario), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 300 (maximum corresponding to the corroded cylinder spill with pooling scenario).
- Accidents resulting in a vehicle-induced fire involving three 48G cylinders during very stable (nighttime) meteorological conditions would have a very low probability of occurrence but could affect a large number of people.
- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009–2028). The results indicate that the maximum risk values would be less than 1 for all accidents, except the following:

TABLE 4.5 Number of Persons with Potential for Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site^a

Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
Corroded cylinder spill, dry conditions	L	Yes	10	No	0	Yes ^f	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	690	Yes	14	Yes	7	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	910	Yes	1,900	Yes	4	Yes	3
Small plane crash, 2 full 48G cylinders	I	Yes	67	Yes	18	Yes ^f	0	No	0

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential adverse effects to an individual.

^f MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE 4.6 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options at the Paducah Site^a

Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
Corroded cylinder spill, dry conditions ^f	L	Yes ^g	0	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	130	Yes ^g	0	Yes	1	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	300	Yes	1	Yes	1	No	0
Small plane crash, 2 full 48G cylinders	I	No	0	No	0	No	0	No	0

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential irreversible adverse effects to an individual.

^f These accidents would result in the largest plume size for the frequency category, although no people would be affected.

^g MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

- *Potential Adverse Effects and Irreversible Adverse Effects:*

Corroded cylinder spill, dry conditions (L, likely), workers

Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible effects was estimated. All the bounding-case accidents shown in Table 4.6 would involve releases of UF₆ and potential exposure to HF and uranium compounds. These exposures could be high enough to result in death for up to 1% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for workers experiencing a range of 0 to 300 irreversible adverse effects, approximately 0 to 3 deaths would be expected. Similarly, of the general public experiencing a range of 0 to 1 irreversible adverse effects, less than 1 death would be expected. These are the maximum potential consequences of the accidents; the upper ends of the ranges result from the assumption of worst-case weather conditions, with the wind blowing in the direction where the highest number of people would be exposed.

4.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries for involved and noninvolved workers is calculated using industry-specific statistics from the Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used respectively for the construction and operational phases of the cylinder transfer facility lifetime; manufacturing fatality and injury rates were used for standard cylinder shipping preparation and overcontainer activities.

Figure 4.10 shows the fatality and injury incidences for all workers associated with packaging cylinders in overcontainers across the range that might be required (i.e., 480 to 1,420 cylinders/yr at the Paducah site). The impacts would increase directly as a function of the numbers of cylinders placed in overcontainers annually. Fatality incidences over the 20-year period of operations would all be less than 1 — ranging from about 0.029 to 0.087. On the basis of the ranges given for overcontainer requirements, the corresponding estimated injury incidence over the 20-year operations period would be from about 39 to 115.

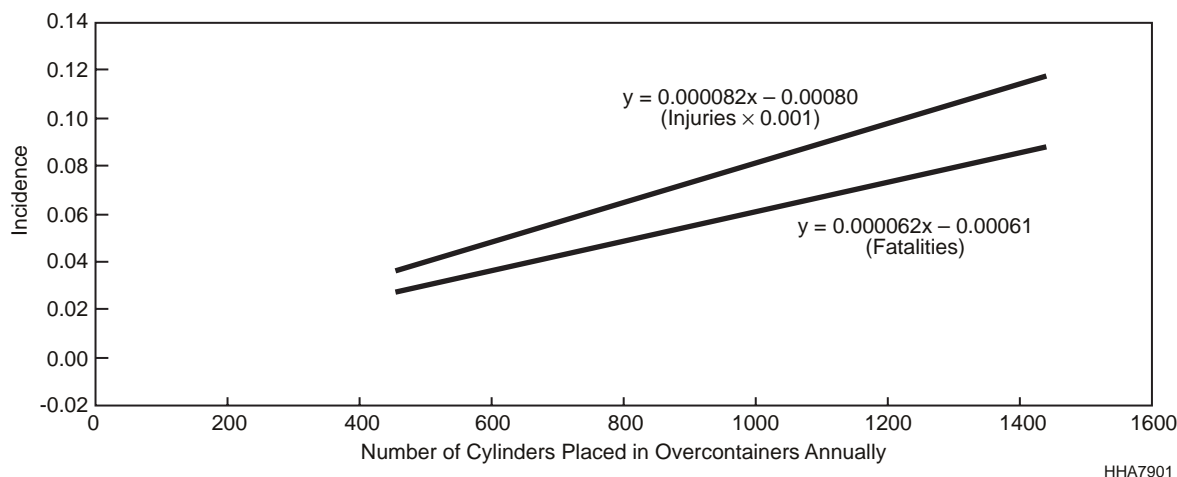


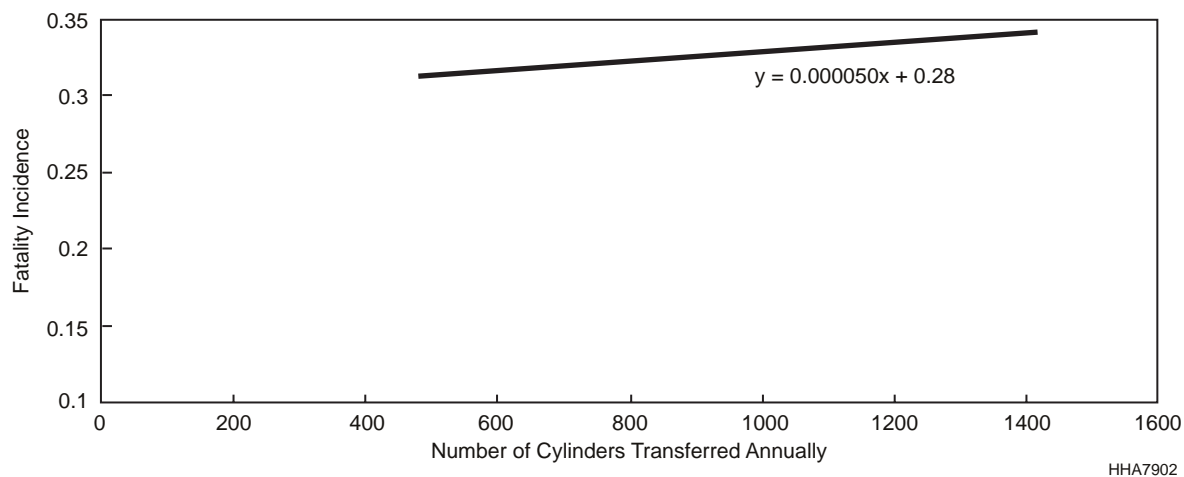
FIGURE 4.10 Worker Fatality and Injury Incidence for Cylinder Overcontainer Activities

Figures 4.11 and 4.12 give the fatality and injury incidences for all workers associated with transferring cylinder contents to new cylinders. It was assumed that any transfer facility would be constructed with a capacity near to or somewhat greater than the maximum number of cylinders expected to require processing (the actual numbers would not be determined until the time of cylinder shipment). However, data in the engineering analysis report (LLNL 1997) also showed that the relationship between number of cylinders processed annually and number of employees required per cylinder processed would not increase linearly. For example, more employees per cylinder would be required to process 100 cylinders than to process 1,000 cylinders. The estimates for the Paducah site would remain relatively constant over the processing rate range assumed. Once the processing rate was above about 500 cylinders per year, fatality and injury incidences would increase very little up to the maximum rate examined of about 1,600 cylinders per year. Fatality incidence for transfer facility construction and operation would be less than 1, ranging from about 0.31 to 0.34. On the basis of the assumed range in cylinder transfer requirements given above, the corresponding injury incidence would range from about 210 to 250.

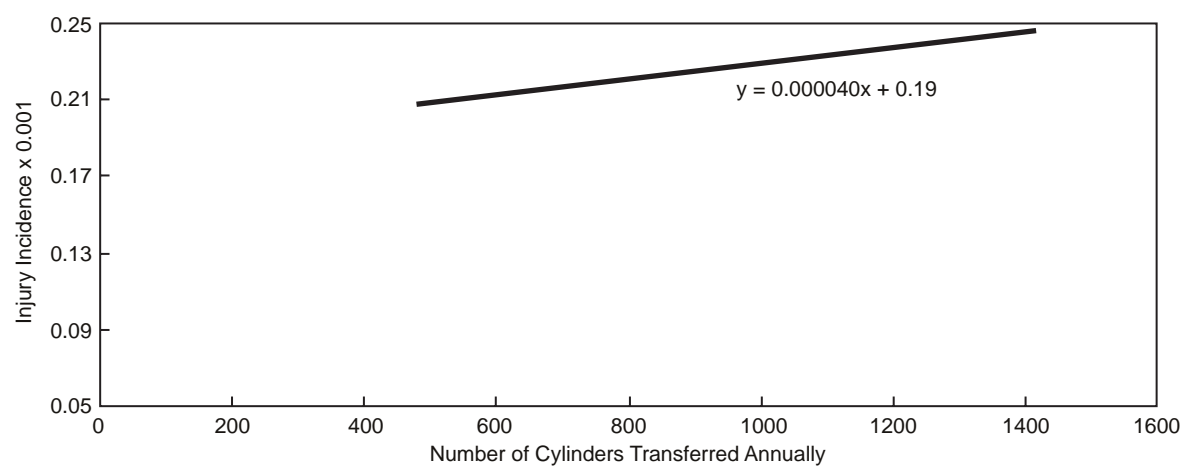
Figure 4.13 gives the fatality and injury incidences for all workers associated with preparation of standard cylinders for transport across the range that might be required at the Paducah site (i.e., from 0 to 940 cylinders/yr). The impacts would increase directly as a function of the numbers of cylinders prepared annually. Fatality incidences would be less than 1, ranging from 0 to about 0.043 at the Paducah site. The corresponding injury incidence would range from 0 to about 87.

4.3.3 Air Quality

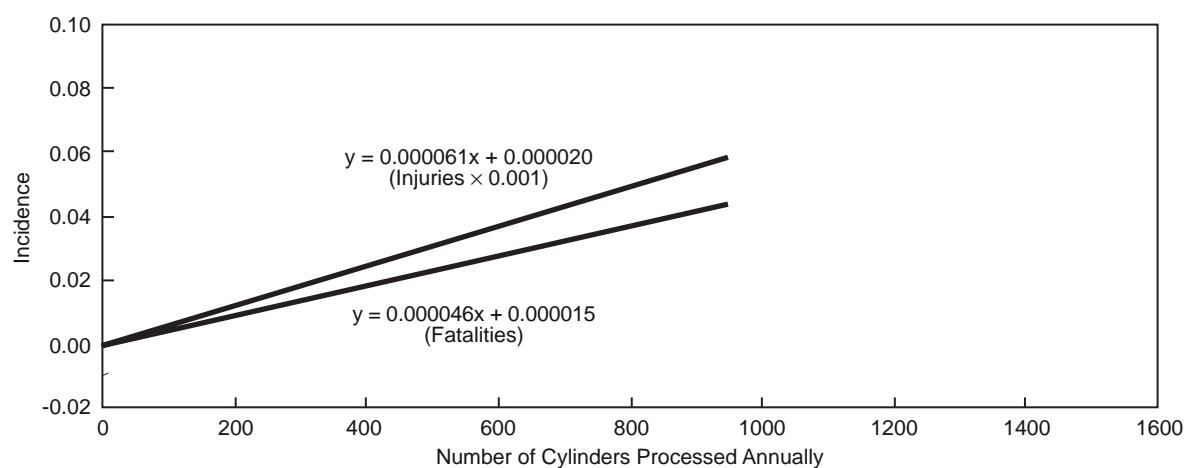
Air quality impacts would result from the emissions associated with two distinct cylinder preparation options: (1) movement of cylinders in preparation for transportation, both those cylinders



HHA7902

FIGURE 4.11 Worker Fatality Incidence for Cylinder Transfer Activities

HHA7903

FIGURE 4.12 Worker Injury Incidence for Cylinder Transfer Activities

HHA7904

FIGURE 4.13 Worker Fatality and Injury Incidence for Standard Cylinder Preparation

requiring overcontainers and standard cylinders, and (2) construction and operation of facilities to transfer contents from substandard cylinders to new ones. These two options are referred to in the following discussion as “overcontainer” and “transfer facility.” No construction would be required for the overcontainer option. Descriptions of the methodology and assumptions are provided in Appendix C of the PEIS and Tschanz (1997a).

Potential air quality impacts for CO, NO_x, and PM₁₀ from implementation of the overcontainer and transfer facility options at the Paducah site are presented in Table 4.7. Ranges of impacts for the overcontainer option represent the assumptions of low to high numbers of cylinders that might be substandard at the time of transportation. All of the impacts for the overcontainer option would be negligible.

Construction of a transfer facility with a capacity to handle 1,600 cylinders per year would cause larger impacts than operation of the facility. The construction impacts would all be less than the applicable air quality standards. The largest impacts, 62% of the standard, would occur for the 24-hour PM₁₀ concentration (Table 4.7). The PM₁₀ concentrations would occur primarily as a result of fugitive dust from land disturbance. The estimated fugitive dust emissions from construction activities were based on a general emission factor that considers only the size of the disturbed area and, therefore, might be overestimated relative to the actual use of construction equipment. Mitigative measures, such as spraying water, would be expected to reduce the PM₁₀ concentrations. More detailed information about the construction activities would be required to accurately assess the likely actual impacts.

Criteria pollutant concentrations during operations would be less than 2% of the values estimated to occur during construction, making all impacts negligible. Process stack emissions during operations would produce an annual average HF concentration of 3.1×10^{-5} g/m³ and UO₂F₂ concentration of 2.1×10^{-6} g/m³.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Paducah site. McCracken County in the Paducah-Cairo Interstate Air Quality Control Region is currently in attainment for all criteria pollutant standards, including ozone. The pollutants most related to ozone formation that could result from the cylinder preparation options at the Paducah site would be HC and NO_x. The potential effects on ozone of those emissions can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in McCracken County, as recorded in the Kentucky Division of Air Quality Control “Emissions Inventory” for 1995 (Hogan 1996). The estimated HC and NO_x emissions of 0.20 and 2.19 tons/yr during operation of the cylinder transfer facility would be only 0.034 and 0.006%, respectively, of the 1995 McCracken County emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the county. Emissions of HC and NO_x from the overcontainer option would be even smaller.

TABLE 4.7 Air Quality Impacts of Cylinder Preparation Options at the Paducah Site

Estimated Maximum Pollutant Concentrations from the Overcontainer Option								
Pollutant	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range (: g/m ³)	Fraction of Standard ^a	Range (: g/m ³)	Fraction of Standard ^a	Range (: g/m ³)	Fraction of Standard ^a	Range (: g/m ³)	Fraction of Standard ^a
CO	23 – 31	0.00078	3.0 – 4.0	0.00040	1.2 – 1.6	–	0.048 – 0.063	–
NO _x	3.5 – 4.7	–	0.46 – 0.62	–	0.18 – 0.24	–	0.0073 – 0.0098	0.000098
PM ₁₀	0.69 – 0.93	–	0.091 – 0.12	–	0.036 – 0.048	0.00032	0.0014 – 0.0019	0.000038
Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility								
Pollutant	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concentration (: g/m ³)	Fraction of Standard ^a	Concentration (: g/m ³)	Fraction of Standard ^a	Concentration (: g/m ³)	Fraction of Standard ^a	Concentration (: g/m ³)	Fraction of Standard ^a
CO	3,200	0.080	1,400	0.14	540	–	50	–
NO _x	450	–	200	–	77	–	7.2	0.072
PM ₁₀	550	–	250	–	93	0.62	8.7	0.17

^a Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

4.3.4 Water and Soil

The cylinder preparation options were assessed for potential impacts on surface water, groundwater, and soils. Details on the methodology and assumptions are presented in Appendix C of the PEIS and Tomasko (1997b).

4.3.4.1 Surface Water

Potential impacts to surface water for the cylinder preparation options could occur during construction, normal operations, and postulated accident scenarios. For the cylinder overcontainer option and preparation of standard cylinders, however, there would be no impacts to surface water because no liquid wastes would be produced during construction and operations (LLNL 1997) and no accident scenarios were identified in the engineering analysis report that would directly release contaminated material to surface water (LLNL 1997). Secondary impacts to surface water would also be negligible because of the small concentrations associated with air deposition.

For the cylinder transfer facility, potential impacts to surface water during construction, normal operations, and accident scenarios would include changes in runoff, changes in quality, and floodplain encroachment.

4.3.4.1.1 Construction

Construction of a cylinder transfer facility with a capacity for 1,600 cylinders per year at the Paducah site would increase runoff because about 15 acres (6.1 ha) of land would be replaced with paved lots and buildings (Table 4.8). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.4% of the land available).

Construction of the cylinder transfer facility would require about 10 million gal/yr (19 gal/min or gpm) of water. This withdrawal would correspond to less than 0.000016% of average river flow and would produce a negligible impact on water levels and floodplains. During construction, the quality of nearby surface water could be affected by releases of wastewater containing small quantities of contaminants such as construction chemicals, organics, and suspended solids. About 5 million gal/yr (9.5 gpm) of construction wastewater would be discharged to nearby surface waters or to an appropriate wastewater sewer under a National Pollutant Discharge Elimination System (NPDES) permit. Once released, the wastewater would eventually be discharged to the Ohio River, resulting in dilution in excess of 12 million:1. All contaminant concentrations would be considerably below regulatory standards.

4.3.4.1.2 Operations

For normal operations of the 1,600/yr cylinder transfer facility at the Paducah site, approximately 9 million gal/yr (17.1 gpm) of water would be withdrawn from surface water (Table 4.8). This withdrawal would represent less than 0.000014% of the average river flow and would produce a negligible impact on water levels and floodplains.

About 7.1 million gal/yr (14 gpm) of wastewater would be discharged to the river during normal operations. This water would consist of sanitary wastewater, blowdown water from the cooling tower, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.000012% of the average river flow and would produce a negligible impact on water levels and floodplains.

In addition to producing physical impacts to surface water, normal operations would also impact surface water quality. Approximately 0.00078 Ci/yr (about 112 : g/L) of uranium would be released to the river at the point of discharge (LLNL 1997). Although the concentration at the outfall would exceed the proposed EPA (1996) MCL of 20 : g/L used as a guideline, the resulting uranium concentration (as well as the concentrations of other chemicals) in the river would be less than 20 : g/L because of dilution (9 million:1).

4.3.4.1.3 Accident Scenarios

No accidents were identified in LLNL (1997) that would directly affect surface water at the Paducah site. Secondary impacts resulting from deposition of airborne contaminants would not be measurable because of low concentrations in the deposited material.

4.3.4.2 Groundwater

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to groundwater because there would be no discharges to the surface (LLNL 1997). For the cylinder transfer facility, impacts could occur during construction and normal

TABLE 4.8 Summary of Environmental Parameters for the Cylinder Transfer Facility

Option	Amount Involved
Disturbed land area (acres)	21
Paved area (acres)	15
Construction water (million gal/yr)	10
Construction wastewater (million gal/yr)	5
Operations water (million gal/yr)	9
Operations wastewater (million gal/yr)	7.1
Radioactive release (Ci/yr)	0.00078

operations; however, there would be no impacts from potential accidents because no accidents were identified in the engineering analysis report (LLNL 1997) that would release contaminants to the ground. Secondary impacts from air deposition would not be measurable because of the small concentrations of deposited material.

4.3.4.2.1 Construction

Construction of the cylinder transfer facility at the Paducah site would result in decreased permeability of about 15 acres (6.1 ha) of land (Table 4.8). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.4% of the land available), the impacts would be local and negligible.

During construction, groundwater quality would also be impacted. For example, stockpiled chemicals could be mobilized by precipitation and infiltrate the surficial aquifer. By following good engineering and construction practices (e.g., covering chemicals to prevent interaction with rain, promptly cleaning up any spills, and providing retention basins to catch and hold contaminated runoff), groundwater concentrations would be less than the EPA guidelines.

4.3.4.2.2 Operations

No impacts to groundwater would occur during normal operations at the Paducah site because no groundwater would be used and there would be no discharges to the ground.

4.3.4.2.3 Accident Scenarios

No accidents associated with cylinder preparation options were identified in LLNL (1997) that would potentially release contaminants to groundwater.

4.3.4.3 Soil

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to soils because there would be no discharges to the ground. For the cylinder transfer facility, the only impacts would occur during construction; during normal operations, there would be no discharges to the ground, and there are no accidents identified in the engineering analysis report (LLNL 1997) that would lead to direct contamination of the soil. Secondary impacts to the soil from air deposition would be negligible because of the small concentrations of contaminants in the deposited material. Impacts from construction of the cylinder transfer facility include changes in topography, permeability, quality, and erosion potential.

At the Paducah site, construction of a cylinder transfer facility with a capacity of 1,600 cylinders per year would disturb 21 acres (8.5 ha) of land (Table 4.8). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.6% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these physical changes, construction could also have a chemical impact on soil. By following good engineering and construction practices (e.g., covering chemicals with tarps, cleaning up spills as soon as they occur, and providing retention basins to catch and hold surface runoff), impacts to soil quality would be negligible.

4.3.5 Socioeconomics

The impacts of cylinder preparation on socioeconomic activity were estimated for an ROI around the Paducah site. Additional details regarding the assessment methodology are presented in Appendix C of the PEIS and Allison and Folga (1997).

Cylinder preparation would likely have a small impact on socioeconomic conditions in the ROI surrounding the site described in Section 2.8. This is partly because a major proportion of expenditures associated with procurement for the preoperation and operation of each preparation option would flow outside the ROI to other locations in the United States, reducing the concentration of local economic effects.

Slight changes in employment and income would occur in the ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required for cylinder preparation activities, and other local investment associated with preoperations and operations. In addition to creating new (direct) jobs, cylinder preparation would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures. Jobs and income created directly by cylinder preparation, together with indirect activity in the ROI, would contribute slightly to a reduction in unemployment in the ROI surrounding the site. Minimal impacts would be expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of preoperating and operating cylinder preparation on regional economic activity, measured in terms of employment and personal income, and on population, housing, and local public revenues and expenditures are discussed in Sections 4.3.5.1 through 4.3.5.3. Impacts are presented for cylinder preparation at the Paducah site for the peak year of preoperations; operations values are averages for the period 2009 through 2028. The impacts of cylinder preparation are given in Table 4.9.

TABLE 4.9 Potential Socioeconomic Impacts of the Cylinder Preparation Options at the Paducah Site

Parameter	Cylinder Overcontainers		Cylinder Transfer Facility		Standard Cylinder Preparation	
	Preoperation ^a	Operations ^b	Construction ^a	Operations ^b	Preoperation ^a	Operations ^b
Economic activity in the ROI						
Direct jobs	<5	120	260	200	<5	60
Indirect jobs	<5	110	130	170	<5	60
Total jobs	<5	230	390	370	<5	120
Direct income (\$ million)	0.1	8	12	10	0.1	4
Total income (\$ million)	0.2	9	14	13	0.1	5
Population in-migration into the ROI	<5	230	440	390	<5	100
Housing demand						
Number of units in the ROI	<5	80	160	140	<5	40
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.3	0.3	0	0.1

^a Impacts are for peak year of preoperation or construction, 2007. The preoperational (construction) phase was assessed from 1999 through 2008.

^b Impacts are the annual averages for operations for the period 2009 through 2028.

4.3.5.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperations for cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table 4.9) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with \$0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers, 230 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with \$9 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.02 percentage points from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table 4.9). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 230 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI. A demand for 80 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 1.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table 4.9). In the first year of operations, 230 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

4.3.5.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 260 direct jobs would be created at the site and 130 additional jobs indirectly in the ROI (Table 4.9) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 390 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with \$14 million of total income produced during the peak year. During the first year of operations of the cylinder transfer facility, 370 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with \$13 million in total income produced. Construction and operation of the transfer facility would result in an increase in the

projected baseline compound annual average growth rate in ROI employment of 0.04 percentage points from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 360 in the peak year (Table 4.9). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 440 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 390 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.02 percentage points from 1999 through 2028.

The cylinder transfer facility would generate a demand for 160 additional rental housing units during the peak year of construction, representing an impact of 10.4% on the projected number of vacant rental housing units in the ROI. The demand for 140 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 3.0% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 440 people would be expected to in-migrate into the ROI, leading to an increase of 0.3% over ROI-forecasted baseline revenues and expenditures (Table 4.9). In the first year of operations, 390 in-migrants would be expected, leading to an increase of 0.3% in local revenues and expenditures.

4.3.5.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table 4.9) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with \$0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 120 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with \$5 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table 4.9). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for standard cylinder preparation would be expected to generate direct and indirect job in-migration of 100 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing no change in the projected number of vacant rental housing units in the ROI. A demand for 40 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table 4.9). In the first year of operations, 100 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

4.3.6 Ecology

Predicted concentrations of contaminants in environmental media were compared with benchmark values of toxic and radiological effects to assess impacts to terrestrial and aquatic biota. Discussion of assessment methodology is presented in Appendix C of the PEIS.

No ecological impacts would be expected during preparation of standard cylinders. Under the cylinder overcontainer option, no site preparation or construction would occur. Normal operations would not result in impacts to surface water, groundwater, or soil (Section 4.3.4). Atmospheric releases of contaminants would include only criteria pollutants, and emission levels would be expected to be extremely low (Section 4.3.3). Therefore, impacts of the cylinder overcontainer option to ecological resources would be negligible.

Impacts to ecological resources could result from construction of a cylinder transfer facility. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a cylinder transfer facility could result from exposure to airborne contaminants or contaminants released to soils, groundwater, or surface waters or changes in surface water or groundwater quality or flow rates.

Site preparation for the construction of a cylinder transfer facility at the Paducah site would require the disturbance of approximately 21 acres (9 ha), including the permanent replacement of approximately 15 acres (6 ha), primarily with structures and paved areas. Existing vegetation would be destroyed during land clearing activities. Determination of the vegetation communities that would be eliminated by site preparation would depend on the exact location of the facility. Communities occurring on undeveloped land at the site are relatively common and well represented in the vicinity of the site; however, impacts to high quality native plant communities might occur if facility construction required disturbance to vegetation communities outside of the currently fenced site area (see Section 4.3.9 for a discussion of land use). Construction of the transfer facility would not be expected to threaten the local population of any species. The loss of up to 21 acres (9 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. Erosion of exposed soil at the construction site could reduce the effectiveness of restoration efforts and create sedimentation

downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table 4.10.

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land-clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities and competition would increase in these areas, potentially reducing the chances of survival or reproductive capacity of displaced individuals. Some wildlife species would be expected to quickly recolonize replanted areas near the facility following completion of construction. The permanent loss of 15 to 21 acres (6 to 9 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the site. Construction of a cylinder transfer facility would be considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section 4.3.4). Thus, construction-derived impacts to aquatic biota would also be expected to be negligible. Wetlands could potentially be impacted by filling or draining during construction. In addition, impacts to wetlands due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the facility were located immediately adjacent to wetland areas. However, impacts to wetlands would be minimized by maintaining a buffer area around wetlands during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Air Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

**TABLE 4.10 Potential Impacts to Ecological Resources
from Construction of the Cylinder Transfer Facility
at the Paducah Site**

Resource	Type of Impact	Degree of Impact
Vegetation	Loss of 21 acres	Moderate adverse
Wildlife	Loss of 15 to 21 acres	Moderate adverse
Wetlands	Loss, degradation	Potential adverse
Aquatic species	Water quality, habitat reduction	Negligible
Protected species	Destruction, habitat loss	Potential adverse

Critical habitat has not been designated for any federal- or state-listed threatened or endangered species at the Paducah site. Prior to construction of the transfer facility, a survey would be conducted for federal- and state-listed threatened, endangered, or candidate species, or species of special concern. Impacts to these species could thus be avoided or, when impacts were unavoidable, appropriate mitigation could be developed.

Water withdrawal from surface waters or groundwater, as well as wastewater discharge, during facility construction and operation could potentially alter water levels. The changes in water levels could in turn affect aquatic ecosystems, including wetlands, such as those located along the periphery of these surface water bodies. However, water-level changes due to water withdrawal and wastewater discharge would be negligible (Section 4.3.4). Therefore, impacts to wetlands and aquatic communities would be expected to be negligible.

Ecological resources in the vicinity of the transfer facility would be exposed to atmospheric emissions from the boiler stack and process stack; however, emission levels would be expected to be extremely low (Section 4.3.3.1), well below concentrations known to adversely affect biota. Resulting impacts to biota would be expected to be negligible. Impacts due to facility operation are shown in Table 4.11.

Effluent discharges to surface waters could contain a number of chemical contaminants. Facility wastewater would have a uranium concentration of about 112 : g/L in the undiluted effluent (Section 4.3.4.1). Dilution of the discharge in the receiving stream by a factor in excess of 150,000 would result in negligible concentrations (Section 4.3.4.1). Thus, impacts to aquatic biota in the vicinity of the outfall would be negligible.

Facility accidents, as discussed in Section 4.3.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors such as location of the accident, season, and meteorological conditions.

TABLE 4.11 Potential Impacts to Ecological Resources from Operation of the Cylinder Transfer Facility at the Paducah Site

Contaminant	Biota	Maximum Exposure	Impact
HF	Wildlife	$3.1 \times 10^{-5} : \text{g/m}^3$	Negligible
UO ₂ F ₂ in air	Wildlife	$2.1 \times 10^{-6} : \text{g/m}^3$	Negligible
Uranium in surface water	Aquatic	112 : g/L	Negligible

4.3.7 Waste Management

Estimates of waste generation were based on the total number of DOE-generated cylinders at the Paducah site. No liquid wastes would be expected as a result of cylinder shipment activities from either standard cylinders or cylinders in overcontainers. The only solid waste generated in these activities would be personal protective equipment and wipes and rags that would be used to remove surface contamination on the cylinders. These wastes are categorized as combustible solid LLW and are shown in Table 4.12. It was assumed that the LLW would be generated during removal of surface contamination and would be independent of the cylinders being standard or substandard. Thus, the amount of waste in this operation would be proportional to the number of cylinders. It was assumed that no cylinder breaches would occur inside the overcontainers during transportation.

The waste input resulting from the cylinder overcontainer operations would have minimal impact on radioactive waste management capabilities at the site or on a national level. The impact on site nonradiological waste management would also be negligible.

The estimated total quantities of solid and liquid wastes generated from activities associated with the construction of a high-capacity (i.e., 1,600 cylinders/yr) cylinder transfer facility are shown in Table 4.13. A facility with this capacity would represent the upper end of the range of cylinders that might require preparation at the Paducah site. The type and quantity of solid and liquid waste expected to be generated from the operation of the cylinder transfer facility are shown in Table 4.14, based on an annual throughput cylinder capacity of 5% of the cylinder inventory. The different types of waste generated during the operation of this facility would include LLW, LLMW, hazardous waste, and nonhazardous waste.

TABLE 4.12 Waste Generated from Activities Associated with Cylinder Overcontainers or Standard Cylinder Preparation^a

Waste Generated		
Waste Type ^b	Annual Volume (m ³ /yr)	Uranium Form
LLW (combustible solids)	12.7	UO ₂ F ₂

^a Decontamination of the overcontainer surfaces was assumed to be performed at the conversion/storage facility prior to the overcontainer being sent back to the site for reuse.

^b It was assumed that the LLW would be generated during removal of surface contamination and would be independent of the cylinder being standard or substandard.

TABLE 4.13 Total Wastes Generated during Construction of a Cylinder Transfer Facility at the Paducah Site^a

Waste Category	Quantity
Hazardous solids	53 m ³
Hazardous liquids	25,000 gal
Nonhazardous solids	
Concrete	99 m ³
Steel	40 tons
Other	763 m ³
Nonhazardous liquids	
Sanitary	3.5 million gal
Other	1.5 million gal

^a 1,600-cylinder/yr capacity.

Source: LLNL (1997).

The primary waste produced in the transfer process would be empty UF₆ cylinders and grouted waste drums. Radioactive or hazardous liquid materials would include decontamination liquids, laboratory liquid wastes, contaminated cleaning solution, lubricants, and paints. Radioactive or hazardous solid wastes would include failed process equipment, high-efficiency particulate air (HEPA) filters, laboratory wastes, wipes, rags, and operator-contaminated clothing. The LLW would be shipped off-site for disposal, and the LLMW and hazardous waste would be shipped off-site for both treatment and disposal. The volume of crushed, empty UF₆ cylinders from the Paducah site would be about 75,000 m³. It is assumed that the treated cylinders would become part of the DOE scrap metal inventory. If a disposal decision was made, the treated cylinders could be disposed of as LLW, representing an addition of about 2% to the total projected DOE complexwide LLW disposal volume.

Overall, the waste input resulting from construction and operation of a transfer facility would add about 7% to the Paducah site LLW generation (see Section 2.9). The input of LLMW and nonhazardous wastes from the transfer facility would represent less than 1% of the site's LLMW or nonhazardous waste loads.

The waste input resulting from the construction and operation of the transfer facility would have minimal impact on radioactive waste management capabilities at the site. The impact on nonradiological site waste management would also be negligible. The impacts of waste resulting

TABLE 4.14 Estimated Annual Radioactive, Hazardous, and Nonhazardous Wastes Generated during Operation of the Cylinder Transfer Facility at the Paducah Site^a

Type of Waste	Description of Waste	Annual Volume (m ³)	Contaminants
<i>Low-Level Waste</i>			
Combustible solids	Gloves, wipes, clothing, etc.	91	17 lb UO ₂ F ₂
Metal, surface-contaminated	Failed equipment	12	16 lb UO ₂ F ₂
Noncombustible compactible solids	HEPA filters	46	54 lb UO ₂ F ₂
	Grouted waste	2.8	135 lb UO ₂ (OH) ₂
Other	Lab packs (chemicals)	0.5	0.75 lb UO ₂ F ₂
<i>Low-Level Mixed Waste</i>			
Lab packs	Chemicals	0.3	0.37 lb UO ₂ F ₂
Inorganic process debris	Failed equipment	0.3	0.37 lb UO ₂ F ₂
Combustible debris	Wipes, etc.	0.3	0.07 lb UO ₂ F ₂
<i>Hazardous Waste</i>			
Organic liquids	Solvents, oil, paint, thinner	0.8	
Inorganic process debris	Failed equipment	1.2	1.5 lb HF, 2 lb NaOH
Combustible debris	Wipes, etc.	1.2	0.75 lb HF, 1 lb NaOH
<i>Nonhazardous Waste</i>			
Nonhazardous solid waste	Nonhazardous solid waste	87	
Nonhazardous liquid waste	Cooling tower blowdown process water, etc.	460	
Recyclable waste	Recyclable waste	180	

^a HEPA = high-efficiency particulate air (filters), HF = hydrogen fluoride, NaOH = sodium hydroxide, UO₂F₂ = uranyl fluoride, UO₂(OH)₂ = uranyl hydroxide.

from the operation of the depleted UF₆ transfer facility on national waste management capabilities would be negligible.

4.3.8 Resource Requirements

The approach taken for assessment of resource requirements was based on a comparison of required resources with national and state-level statistics on consumption of commodities

(U.S. Department of Commerce 1997, 1999). More detailed information on the methodology is presented in Appendix C of the PEIS.

Cylinder overcontainers would be constructed primarily from steel purchased from existing steel vendors. The preliminary overcontainer design requires approximately 8,000 lb (3,600 kg) of steel per overcontainer (LLNL 1997). Resources would be required only for the construction of overcontainers. No substantial resources would be required for the use of the overcontainers. Because the overcontainers would be reusable, it is estimated that approximately 350 overcontainers would be required. This total assumes a 10% contingency for spares, unforeseen delays, and the few overcontainers that might be needed at the cylinder treatment facility. The total amount of steel required for the overcontainers would be about 2,780,000 lb (1,270,000 kg). On the basis of the total steel required for construction of overcontainers, no impact on local or national steel availability or production would be expected (Standard & Poor's 1996; U.S. Bureau of the Census 1996). No other materials of significant quantity would be required.

Resource needs for the cylinder transfer facility are presented in Table 4.15 as utilities consumed during construction and operations. The facility was assumed to operate 24 hours per day, 7 days per week, and 292 days per year for an 80% plant availability during operations.

The process equipment would be purchased from equipment vendors. The total quantities of commonly used construction material (i.e., steel) for equipment would be minor as compared to the quantities for construction. The primary specialty material used for equipment fabrication is at most approximately 7 tons of Monel. The material quantities required for construction and operation of the cylinder transfer facility would be minor compared to local and national supplies.

4.3.9 Land Use

No impacts to land use from cylinder overcontainer operations at the Paducah site would be expected. No additional land would be required, and no new construction would be necessary. Existing handling and support equipment would be utilized with no modifications required (LLNL 1997). No off-site traffic impacts would be encountered during operations because the required labor force would not appreciably affect local traffic patterns or flows.

Impacts to land use from the construction and operation of a cylinder transfer facility would be negligible and limited to temporary disruptions to contiguous land parcels and potential minor traffic disruptions from peak-year construction activities. Areal requirements would be small (approximately 21 acres or less).

TABLE 4.15 Resource Requirements for Construction and Operation of the Cylinder Transfer Facility at the Paducah Site

Material/Resource	Total Requirement
<i>Construction</i>	
Utilities	
Electricity (GWh)	40
Solids	
Concrete (yd ³)	23,000
Steel (tons)	9,000
Liquids (million gal)	
Fuel	1.8
Gases (gal)	
Industrial gases	5,000
Specialty material (tons) (Monel)	7
<i>Operations</i>	
Utilities	
Electricity (GWh/yr)	14.6
Solids (lb)	
Cement	2,700
Potassium hydroxide	4,600
Liquids	
Sulfuric acid (lb/yr)	2,400
Hydrochloric acid (lb/yr)	1,900
Sodium hydroxide (lb/yr)	1,500
Liquid fuel (gal/yr)	6,000
Gases	
Natural gas (million scf/yr) ^a	48.5

^a scf = standard cubic feet.

The peak construction labor force for the cylinder transfer facility could result in potential off-site traffic impacts in the vicinity of the site, although such impacts would be negligible and would ease as construction neared completion.

4.3.10 Cultural Resources

No impacts to cultural resources would be expected at the Paducah site as a result of the cylinder overcontainer option for cylinder preparation. Impacts could result from the cylinder transfer option during construction of the transfer facility. Specific impacts cannot be determined at this time and would depend on the exact location of a facility within the site and whether eligible cultural resources existed on or near that location. Operation of the transfer facility would not affect cultural resources.

4.3.11 Environmental Justice

The analysis of human health and environmental impacts associated with the cylinder overcontainer operations (Sections 4.3.1 through 4.3.9) indicates that no high and adverse human health effects would be expected at the Paducah site during normal operations. Consequently, no particular segment of the population, including minority and low-income persons, would be disproportionately affected. The results of accident analyses for cylinder preparation did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than 1).

The construction and operation of a cylinder transfer facility at the Paducah site would not result in disproportionate effects on minority or low-income populations. The analysis of human health effects and environmental impacts associated with a cylinder transfer facility (Sections 4.3.1 through 4.3.9) indicates that no high and adverse human health effects or environmental impacts would be expected.

4.3.12 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if either of the cylinder preparation options was implemented include impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, as well as impacts associated with decontamination and decommissioning of the cylinder transfer facilities. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- Consideration of these impacts would not contribute to differentiation among the alternatives and therefore would not affect the decisions to be made in the ROD for the PEIS or

- Impacts to the visual environment, recreational resources, and noise levels would be expected to stay the same as they are because cylinder preparation activities would be similar to the cylinder management activities currently ongoing at the Paducah site.

4.4 POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH PREPARING THE ENTIRE PADUCAH SITE CYLINDER INVENTORY FOR SHIPMENT OR STORAGE

After the draft PEIS was completed, management responsibility for approximately 8,600 additional cylinders of depleted UF₆ at the Paducah site was transferred from USEC to DOE by the signing of two MOAs associated with the privatization of USEC (DOE and USEC 1998a,b). To account for uncertainties associated with the number of cylinders that would be transferred from USEC to DOE in the future and to provide a bounding analysis of environmental impacts, the final PEIS evaluated the environmental impacts of managing an additional 12,000 cylinders at the Paducah site. These analyses are summarized in Chapter 6 of the PEIS; impacts associated with cylinder preparation for the entire Paducah site inventory (including USEC-generated cylinders) are summarized in this Section 4.4.2.

4.4.1 Approach Used to Evaluate the Environmental Impacts of Cylinder Preparation for the USEC Cylinders

The number of cylinders that would not meet DOT requirements at the time of shipment is unknown. A probable range of values determined by the current cylinder conditions was assumed for the analyses. To assess the site-specific impacts from the addition of the USEC cylinders, it was assumed that the cylinder preparation options at the Paducah site (i.e., preparation of standard cylinders, use of overcontainers, or operation of a cylinder transfer facility) would be extended for about 6 years to accommodate the additional inventory.

4.4.2 Potential Environmental Impacts from Preparation of the Entire Paducah Site Cylinder Inventory (DOE- and USEC-Generated Cylinders) for Shipment or Long-Term Storage

4.4.2.1 Human Health and Safety — Normal Operations

4.4.2.1.1 Workers

The annual doses to workers and the general public from cylinder preparation activities would not increase with the addition of the USEC-cylinders, because it is assumed that the length

of operations would be increased from 20 to 26 years rather than increasing the annual activity levels. For cylinder overcontainer options, the total dose to involved workers would be increased to range from 250 to 740 person-rem for the entire cylinder inventory. The corresponding estimated total number of LCFs would range from 0.1 to 0.3. Noninvolved workers have no radiation exposures associated with the cylinder overcontainer options.

For cylinder transfer options, the involved worker total dose range would increase to 850 to 1,500 person-rem. The corresponding estimated total number of LCFs for involved workers would range from 0.3 to 0.6 LCF. For noninvolved workers, the annual doses to the MEI reported in Table 4.1 would not change. The total collective dose to noninvolved workers would increase to range from 7.2×10^{-5} to 1.8×10^{-4} ; total LCFs would range from 3×10^{-8} to 7×10^{-8} .

For preparation of standard cylinders, the involved worker total dose range would increase to 0 to 310 person-rem; the corresponding total number of LCFs would be 0 to 0.12. There are no radiation exposures for noninvolved workers associated with preparation of standard cylinders.

No chemical impacts to workers would be associated with the increased cylinder inventory. The estimated maximum hazard index for the noninvolved transfer facility worker MEI of 3.2×10^{-8} given in Section 4.3.1.2 would not change; this level is far below the threshold level for adverse effects.

4.4.2.1.2 General Public

Members of the general public have no radiation exposures associated with the cylinder overcontainer or standard cylinder preparation options. For cylinder transfer options, the annual dose to the general public MEI reported in Table 4.1 would not change with the addition of the USEC cylinders. The total collective dose to the general public would increase to range from 1.6×10^{-3} to 4.1×10^{-3} ; total LCFs would range from 8×10^{-7} to 2×10^{-6} .

No chemical impacts to the general public would be associated with the increased cylinder inventory. The estimated maximum hazard index for the general public MEI of 2.8×10^{-6} given in Section 4.3.1.2 would not change; this level is far below the threshold level for adverse effects.

4.4.2.2 Human Health and Safety — Accident Conditions

4.4.2.2.1 Physical Hazards

The total number of worker fatalities and injuries associated with cylinder overcontainer options for the entire inventory at the Paducah site (including USEC cylinders) would range from 0.04 to 0.12 fatalities and from about 55 to 160 injuries. The total numbers associated with cylinder

transfer options for the entire inventory would range from 0.44 to 0.48 fatalities and 300 to 360 injuries. For preparation of standard cylinders, fatalities would range from 0 to 0.061 and injuries would range from 0 to 124.

4.4.2.2 Accidents Involving Releases of Radiation or Chemicals

For accident consequences, impacts would be the same as those previously discussed for the DOE-generated cylinders (Section 4.3.2), because the types of accidents assessed would involve only a limited amount of material that would be at risk under accident conditions. Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC-generated cylinders, this increase is not expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used in the PEIS.

4.4.2.3 Transportation

The cylinder overcontainer option is not associated with transportation risks. The only transportation risks associated with a cylinder transfer facility would be from minor amounts of chemicals used at the facility and small amounts of LLW and LLMW generated at the facility. See Section J.3.3 of the PEIS for a more detailed discussion of the transportation risks.

4.4.2.4 Air Quality

Impacts to air quality from cylinder preparation options for the total cylinder inventory would be the same as those presented in Section 4.3.3 for the DOE-only inventory. This is because air quality impacts are presented as annual impacts, and the size of the facility (for cylinder transfer options) and the annual levels of operations for all options would not increase. The increased inventory would be accommodated through an increased length of operations.

4.4.2.5 Water and Soil

There would be no impacts to surface water, groundwater, or soil from the cylinder overcontainer option for the entire cylinder inventory because no releases are associated with this option. The annual water requirement for a cylinder transfer facility would not change from that presented in Section 4.3.4.1 (i.e., about 9 million gal/yr), because the size of the facility would not change. However, the facility would be operated for an additional 6 years.

4.4.2.6 Socioeconomics

The annual socioeconomic impacts from cylinder preparation activities would be the same as those for the DOE-generated cylinders only estimated in Section 4.3.5, but the period of operation would be extended by 6 years. Construction impacts would not change for the cylinder preparation options because facility sizes would remain the same.

4.4.2.7 Ecology

Impacts to ecological resources from the preparation of the entire cylinder inventory (USEC- and DOE-generated) for shipment would be minimal, as discussed in Section 4.3.6. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects. (Benchmarks are given in Section C.3.3 of the PEIS.) In addition, construction activities for a cylinder transfer facility would likely take place in previously disturbed areas and thus would have minimal ecological impacts.

4.4.2.8 Waste Management

The annual volume of LLW waste generation from use of cylinder overcontainers or standard cylinder preparation would remain at 12.7 m³/yr (Table 4.12); the total amount would increase from about 250 to 330 m³. The impact of this increase on site or national radioactive waste management capabilities would be negligible.

The annual levels of LLW, LLMW, hazardous waste, and nonhazardous waste generated from construction and operation of a cylinder transfer facility would not change with consideration of the additional USEC cylinders, but operations would continue for 6 additional years. Impacts to Paducah site waste management capabilities would remain minimal, as discussed in Section 4.3.7. The maximum total volume of crushed, empty UF₆ cylinders generated at the Paducah site over 26 years would increase to about 110,000 m³, representing a negligible to low impact (about a 3% addition) to the total projected DOE complexwide disposal volume.

4.4.2.9 Resource Requirements

In general, the addition of the USEC cylinders would not change the resource requirements for cylinder preparation. Cylinder overcontainers would be reused, so the total number required would remain about 350. The construction and operation requirements identified in Section 4.3.8 would remain the same, but operations would continue for an additional 6 years. Impacts to local and national supplies of resources would be minor.

4.4.2.10 Land Use

If a transfer facility were built for cylinder preparation, the land use requirements would be the same as those for the DOE-generated cylinders only described in Section 4.3.9, because the facility operational period would increase, not the facility size.

4.4.2.11 Cultural Resources

No impacts to cultural resources would be expected at the Paducah site from the cylinder overcontainer option. Impacts from a cylinder transfer facility cannot be determined at this time and would depend on the exact location within the site and whether eligible cultural resources existed on or near that location.

4.4.2.12 Environmental Justice

No disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah site in association with the cylinder preparation for the entire cylinder inventory (DOE- and USEC-generated cylinders).

5 ENVIRONMENTAL IMPACTS OF OPTIONS FOR CONVERSION OF UF_6 TO OXIDE OR METAL AT THE PADUCAH SITE

Conversion of depleted UF_6 to another chemical form would be required for most alternative management strategies. Three different conversion options were analyzed in the PEIS: (1) conversion to triuranium octaoxide (U_3O_8), (2) conversion to uranium dioxide (UO_2), and (3) conversion to uranium metal. The specific conversion option considered under each of the alternatives is shown in Table 5.1. Because of their high chemical stability and low solubility, uranium oxides (i.e., U_3O_8 and UO_2) are considered for the storage and disposal alternatives. High-density UO_2 and uranium metal are considered for the use alternatives (e.g., spent nuclear fuel radiation shielding applications). Other details concerning the characteristics of the different chemical forms of uranium are given in Appendix A of the PEIS.

Conversion of depleted UF_6 to another chemical form would take place at a stand-alone industrial plant dedicated to the conversion process. A representative conversion plant layout is shown in Figure 5.1; the actual plant layout would depend on the specific conversion option and technology selected, as well as on certain site characteristics. In general, the plant would be capable of receiving depleted UF_6 cylinders on trucks or railcars, temporarily storing a small inventory of full cylinders, processing the depleted UF_6 to another chemical form, and storing the converted uranium product and any other products until shipment off-site. The empty cylinders would be stored until transfer to a cylinder treatment facility, which is assumed to be located at the conversion plant site. It is estimated that a typical conversion plant would cover an area of approximately 20 acres (8 ha) (LLNL 1997).

In general, potential environmental impacts would occur (1) during construction of a conversion facility, (2) during operations of the facility, and (3) during postulated accidents. The potential impacts associated with facility construction would result from typical land-clearing and construction activities. Potential impacts during operations would occur primarily to workers during handling operations and to the public as a result of routine releases of small amounts of contaminants through exhaust stacks and treated liquid effluent discharges. In addition, potential impacts to

Conversion Options

Conversion of depleted UF_6 to another chemical form is required for a number of storage, use, and disposal management alternatives. The principal conversion options considered are as follows:

Conversion to U_3O_8 . This chemical form is a stable, low-solubility oxide considered for storage and disposal. Two different technologies were considered for conversion to U_3O_8 .

Conversion to UO_2 . This stable, low-solubility oxide is considered for storage, disposal, and potential use as shielding material. Three different technologies were considered for conversion to UO_2 .

Conversion to Metal. Metallic depleted uranium is considered for use as shielding material. Two different technologies were considered for conversion to metal.

TABLE 5.1 Summary of the Conversion Options Considered for Each Programmatic Management Alternative

Option	Option Considered for Management Alternative ^a					
	No Action	Long-Term Storage		Use		
		UF ₆	Oxide	Uranium Oxide	Uranium Metal	Disposal
Conversion to U ₃ O ₈	–	–	X	–	–	X
Conversion to UO ₂	–	–	X	X	–	X
Conversion to metal	–	–	–	–	X	–

^a X = option considered; – = option not considered.

workers and the public from processing or storage might occur as a result of accidents that release hazardous materials.

The environmental impacts from the conversion options were evaluated based on the information described in the engineering analysis report (LLNL 1997). For each of the three conversion options (conversion to U₃O₈, UO₂, or metal), the engineering analysis report provides preconceptual facility design data, including descriptions of facility layouts; resource requirements; estimates of effluents, wastes, and emissions; and estimates of potential accident scenarios. Within each conversion option, several technologies or chemical processes that could be used to produce the same uranium end product are described (two are considered for conversion to U₃O₈, three for conversion to UO₂, and two for conversion to metal). Some of these technologies have not been demonstrated on a commercial scale but were considered to provide an estimate of the range of the environmental impacts that might be associated with each of the conversion options. All facility designs were based on a single plant sized to process the entire inventory of DOE-generated depleted UF₆ cylinders over a 20-year period (approximately 2,300 cylinders per year).

In the PEIS, the analyses of the conversion options assumed that the three current storage sites were representative of sites that might actually be used for these activities. Site-specific data for each of the three current storage sites (Paducah, Portsmouth, and K-25) were used to conduct the analyses. After the analyses were completed, the results were aggregated and presented as a range that accounted for differences in sites as well as differences in technologies that might be used in the future. In this report, ranges of impacts from the different conversion technologies examined in the PEIS are presented specifically for the Paducah site. Although the analyses for conversion used some data for the Paducah site, these analyses are not sufficient to completely fulfill NEPA

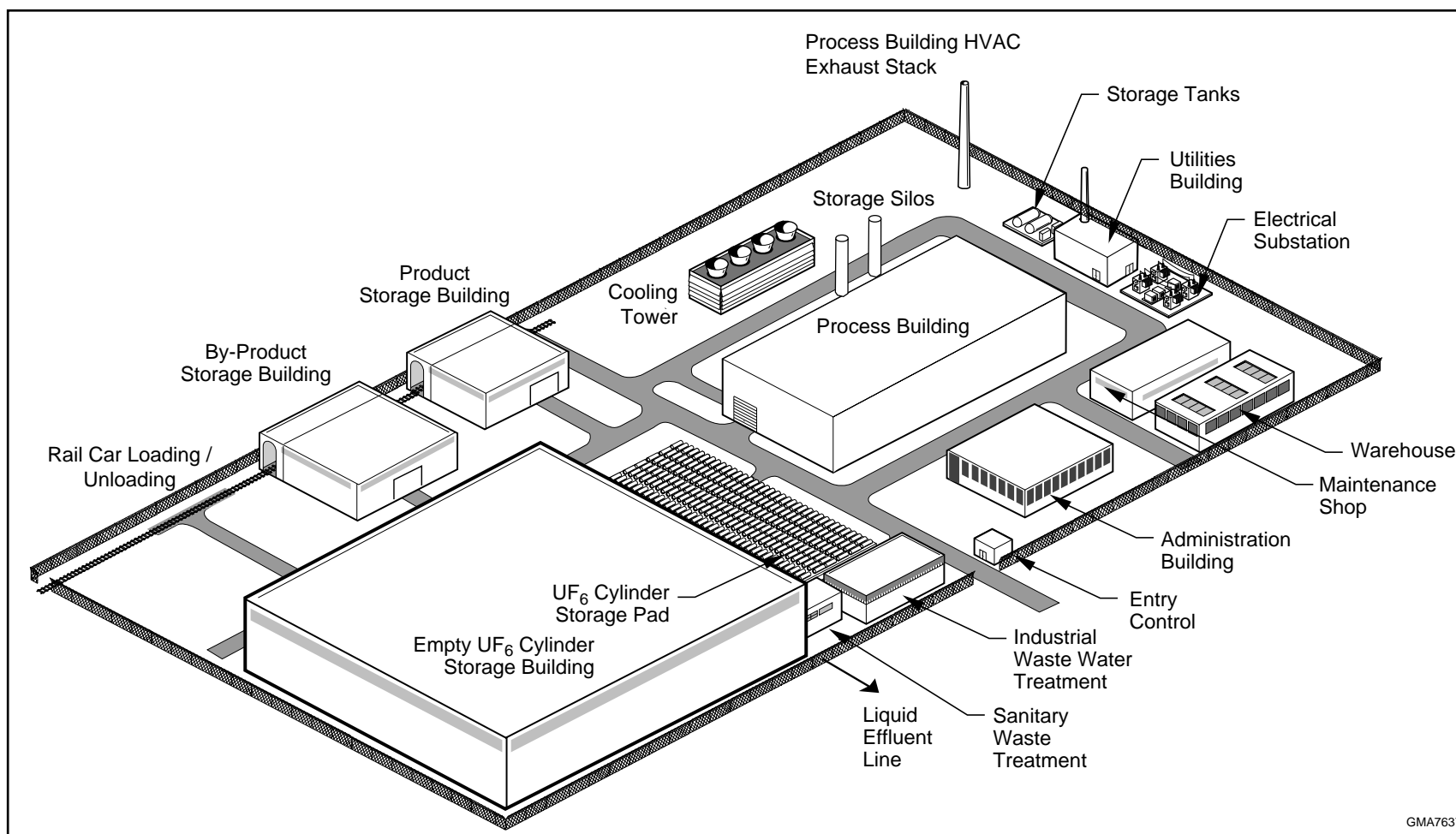


FIGURE 5.1 Representative Site Layout for a Conversion Facility

requirements for site-specific environmental analyses for an actual conversion facility. For such analyses, detailed technology design and effluent data and information on the exact location of the proposed facilities within the Paducah site must be available.

5.1 SUMMARY OF CONVERSION OPTION IMPACTS

The potential environmental impacts for the three conversion options using the Paducah site as a representative location are compared in Table 5.2. For each conversion option, the potential environmental impacts are presented as a range within each area of impact. This range is intended to provide a reasonable estimate of the magnitude of impacts, taking into account the uncertainty relative to the specific technologies that could ultimately be selected for conversion. The range of impacts results from fundamental differences among the technologies within each conversion option. A more detailed assessment of specific technologies and site conditions will be conducted, as appropriate, as part of the second phase (tier) of the programmatic NEPA approach. Additional discussion and details related to the assessment methodologies and results for individual areas of impact are provided in the remainder of this section.

After the draft PEIS was completed, management responsibility for approximately 11,200 additional cylinders of depleted UF_6 was transferred from USEC to DOE. To provide a bounding analysis of environmental impacts, the final PEIS evaluated the environmental impacts of managing an additional 15,000 cylinders. The impacts associated with conversion of the total inventory (including USEC-generated cylinders) are summarized in Section 5.4 of this document. A summary of the estimated environmental impacts associated with conversion of the DOE-generated cylinders only and the total cylinder inventory (DOE-generated plus USEC-generated) is presented in Table 5.2.

5.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the different conversion options considered in the assessment of conversion impacts (Table 5.3). The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report includes much more detailed information, such as descriptions of facility layouts; resource requirements; estimates of effluents, wastes, and emissions; and estimates of potential accident scenarios.

All of the conversion options would involve the removal of depleted UF_6 from the storage cylinders, resulting in a large number of empty cylinders. These empty cylinders would contain approximately 22 lb (10 kg) of depleted UF_6 (Charles et al. 1991), called “heels.” For assessment purposes, it has been assumed that a cylinder treatment facility would be constructed to wash the empty cylinders. This facility has been assumed to be an independent, or “stand-alone,” facility, although it could be integrated directly into the design of the conversion plant. The facility would be co-located with the conversion plant.

TABLE 5.2 Summary of Conversion Option Impacts for the Paducah Site^a

Impacts from Conversion to U ₃ O ₈	Impacts from Conversion to UO ₂	Impacts from Conversion to Metal	Impacts from Cylinder Treatment ^b
Human Health – Normal Operations: Radiological			
Involved Workers:	Involved Workers:	Involved Workers:	Involved Workers:
Total collective dose: 820 person-rem [1,100 person-rem]	Total collective dose: 980 – 1,100 person-rem [1,300 – 1,400 person-rem]	Total collective dose: 650 – 1,300 person-rem [850 – 1,700 person-rem]	Total collective dose: 320 person-rem [420 person-rem]
Total number of LCFs: 0.3 LCF [0.4 LCF]	Total number of LCFs: 0.4 LCF [0.5 – 0.6 LCF]	Total number of LCFs: 0.3 – 0.5 LCF [0.3 – 0.7 LCF]	Total number of LCFs: 0.1 LCF [0.2 LCF]
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
Annual dose to MEI: 1.6×10^{-3} mrem/yr	Annual dose to MEI: 3.2×10^{-3} – 6.1×10^{-3} mrem/yr	Annual dose to MEI: 6.8×10^{-4} – 4.8×10^{-3} mrem/yr	Annual dose to MEI: 4.9×10^{-6} mrem/yr
Annual cancer risk to MEI: 6×10^{-10} per year	Annual cancer risk to MEI: 1×10^{-9} – 2×10^{-9} per year	Annual cancer risk to MEI: 3×10^{-10} – 2×10^{-9} per year	Annual cancer risk to MEI: 2×10^{-12} per year
Total collective dose: 0.04 person-rem [0.06 person-rem]	Total collective dose: 0.08 – 0.16 person-rem [0.11 – 0.21 person-rem]	Total collective dose: 0.02 – 0.13 person-rem [0.03 – 0.2 person-rem]	Total collective dose: 1.3×10^{-4} person-rem [1.7×10^{-4} person-rem]
Total number of LCFs: 2×10^{-5} LCF	Total number of LCFs: 3×10^{-5} – 6×10^{-5} LCF [4×10^{-5} – 8×10^{-5} LCF]	Total number of LCFs: 7×10^{-6} – 5×10^{-5} LCF [1×10^{-5} – 8×10^{-5} LCF]	Total number of LCFs: 5×10^{-8} LCF [7×10^{-8} LCF]
General Public:	General Public:	General Public:	General Public:
Annual dose to MEI: 4.9×10^{-3} mrem/yr	Annual dose to MEI: 9.7×10^{-3} – 1.9×10^{-2} mrem/yr	Annual dose to MEI: 2.1×10^{-3} – 1.5×10^{-2} mrem/yr	Annual dose to MEI: 1.5×10^{-5} mrem/yr
Annual cancer risk to MEI: 2×10^{-9} per year	Annual cancer risk to MEI: 5×10^{-9} – 9×10^{-9} per year	Annual cancer risk to MEI: 1×10^{-9} – 7×10^{-9} per year	Annual cancer risk to MEI: 8×10^{-12} per year
Total collective dose to population within 50 miles: 0.86 person-rem [1.1 person-rem]	Total collective dose to population within 50 miles: 1.7 – 3.2 person-rem [2.2 – 4.2 person-rem]	Total collective dose to population within 50 miles: 0.36 – 2.6 person-rem [0.47 – 3.4 person-rem]	Total collective dose to population within 50 miles: 0.006 person-rem [0.008 person-rem]
Total number of LCFs in population within 50 miles: 0.0004 LCF [0.0006 LCF]	Total number of LCFs in population within 50 miles: 0.0009 – 0.002 LCF [0.001 – 0.002 LCF]	Total number of LCFs in population within 50 miles: 0.0002 – 0.001 LCF [0.0002 – 0.002 LCF]	Total number of LCFs in population within 50 miles: 1×10^{-6} LCF [4×10^{-6} LCF]

TABLE 5.2 (Cont.)

Impacts from Conversion to U ₃ O ₈	Impacts from Conversion to UO ₂	Impacts from Conversion to Metal	Impacts from Cylinder Treatment ^b
Human Health – Normal Operations: Chemical			
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts	General Public: No impacts	General Public: No impacts
Human Health – Accidents: Radiological			
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 9.2 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 2.3 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.43 rem
Risk of LCF to MEI: 4×10^{-3}	Risk of LCF to MEI: 9×10^{-4}	Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 2×10^{-4}
Collective dose: 380 person-rem	Collective dose: 94 person-rem	Collective dose: 5.3 person-rem	Collective dose: 17 person-rem
Number of LCFs: 0.2	Number of LCFs: 0.04	Number of LCFs: 2×10^{-3}	Number of LCFs: 0.007
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.068 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.013 rem
Risk of LCF to MEI: 1×10^{-4}	Risk of LCF to MEI: 3×10^{-5}	Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 5.3 person-rem	Collective dose to population within 50 miles: 1.3 person-rem	Collective dose to population within 50 miles: 9 person-rem	Collective dose to population within 50 miles: 0.45 person-rem
Number of LCFs in population within 50 miles: 0.003 LCF	Number of LCFs in population within 50 miles: 0.0007 LCF	Number of LCFs in population within 50 miles: 0.005 LCF	Number of LCFs in population within 50 miles: 0.0002 LCF

TABLE 5.2 (Cont.)

Impacts from Conversion to U ₃ O ₈	Impacts from Conversion to UO ₂	Impacts from Conversion to Metal	Impacts from Cylinder Treatment ^b
Human Health – Accidents: Chemical			
Bounding accident frequency: less than once in 1 million years	Bounding accident frequency: less than once in 1 million years	Bounding accident frequency: less than once in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 770 persons	Number of persons with potential for adverse effects: 770 persons	Number of persons with potential for adverse effects: 770 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 420 persons	Number of persons with potential for irreversible adverse effects: 420 persons	Number of persons with potential for irreversible adverse effects: 420 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 19,000 persons	Number of persons with potential for adverse effects: 19,000 persons	Number of persons with potential for adverse effects: 19,000 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 1,700 persons	Number of persons with potential for irreversible adverse effects: 1,700 persons	Number of persons with potential for irreversible adverse effects: 1,700 persons	Number of persons with potential for irreversible adverse effects: 0 persons
Human Health — Accidents: Physical Hazards			
Construction and Operations: All Workers: 0.35 [0.46] fatality, approximately 290 [380] injuries	Construction and Operations: All Workers: 0.59 [0.78] fatality, approximately 490 [650] injuries	Construction and Operations: All Workers: 0.55 [0.73] fatality, approximately 490 [650] injuries	Construction and Operations: All Workers: 0.19 [0.25] fatality, approximately 170 [220] injuries

TABLE 5.2 (Cont.)

Impacts from Conversion to U ₃ O ₈	Impacts from Conversion to UO ₂	Impacts from Conversion to Metal	Impacts from Cylinder Treatment ^b
<i>Air Quality</i>			
Construction: 24-hour PM ₁₀ concentration potentially as large as 65% of standard. Concentrations of other criteria pollutants all below 15% of respective standards.	Construction: 24-hour PM ₁₀ concentration potentially as large as 90% of standard. Concentrations of other criteria pollutants all below 30% of respective standards.	Construction: 24-hour PM ₁₀ concentration potentially as large as 90% of standard. Concentrations of other criteria pollutants all below 20% of respective standards.	Construction: 24-hour PM ₁₀ concentration potentially as large as 25% of standard. Concentrations of other criteria pollutants all below 10% of respective standards.
Operations: 8-hour CO concentration potentially as large as 2% of standard.	Operations: 8-hour CO concentration potentially as large as 3% of standard.	Operations: 8-hour CO concentration potentially as large as 4% of standard.	Operations: Concentrations of all criteria pollutants below 0.06% of respective standards.
<i>Water</i>			
Construction: None to negligible physical impacts; concentrations less than applicable standards	Construction: None to negligible physical impacts; concentrations less than applicable standards	Construction: None to negligible physical impacts; concentrations less than applicable standards	Construction: None to negligible physical impacts; concentrations less than applicable standards
Operations: None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards	Operations: None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards	Operations: None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards	Operations: None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards
<i>Soil</i>			
Construction: None to negligible impacts	Construction: None to negligible impacts	Construction: None to negligible impacts	Construction: None to negligible impacts
Operations: None to negligible physical impacts; concentrations less than applicable guidelines	Operations: None to negligible physical impacts; concentrations less than applicable guidelines	Operations: None to negligible physical impacts; concentrations less than applicable guidelines	Operations: None to negligible physical impacts; concentrations less than applicable guidelines

TABLE 5.2 (Cont.)

Impacts from Conversion to U ₃ O ₈	Impacts from Conversion to UO ₂	Impacts from Conversion to Metal	Impacts from Cylinder Treatment ^b
Socioeconomics^c			
Jobs: 240-250 peak year, construction, 200-210/year over 20 years, operations [over 26 years, operations]	Jobs: 330-630 peak year, construction, 230-360/year over 20 years, operations [over 26 years, operations]	Jobs: 380-440 peak year, construction, 210-370/year over 20 years, operations [over 26 years, operations]	Jobs: 100 peak year, construction, 130/year over 20 years, operations [over 26 years, operations]
Income: \$11 million peak year, construction, \$10 million/year over 20 years, operations [over 26 years, operations]	Income: \$15-28 million peak year, construction, \$11-18 million/year over 20 years, operations [over 26 years, operations]	Income: \$12-16 million peak year, construction, \$10-18 million/year over 20 years operations [over 26 years operations]	Income: \$5 million peak year, construction; \$10 million/year over 20 years, operations [over 26 years, operations]
Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	Construction and Operations: Negligible to low impacts to ROI employment and population growth rates and to public finances; potential moderate impacts to vacant housing	Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Ecology			
Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential moderate impacts to vegetation and wildlife
Operations: Negligible impacts	Operations: Negligible impacts	Operations: Negligible impacts	Operations: Negligible impacts
Waste Management			
Potential moderate impacts to site, regional, or national waste management operations	Potential moderate impacts to site, regional, or national waste management operations	Potential moderate impacts to site, regional, or national waste management operations	Negligible to low impacts to national waste management operations from disposal of crushed cylinders

TABLE 5.2 (Cont.)

Impacts from Conversion to U ₃ O ₈	Impacts from Conversion to UO ₂	Impacts from Conversion to Metal	Impacts from Cylinder Treatment ^b
Resource Requirements			
No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale
Land Use^d			
Construction: Use of approximately 20 acres; negligible impacts	Construction: Use of approximately 22 to 31 acres; negligible impacts	Construction: Use of approximately 23 to 26 acres; negligible impacts	Construction: Use of approximately 9 acres; negligible impacts
Operations: Use of approximately 13 acres; negligible impacts	Operations: Use of approximately 14 to 20 acres; negligible impacts	Operations: Use of approximately 15 to 16 acres; negligible impacts	Operations: Use of approximately 5 acres; negligible impacts

^a In general, the overall environmental consequences from managing the total cylinder inventory (total of USEC-generated and DOE-generated cylinders) are the same as those from managing the DOE-generated cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE cylinders only. CO = carbon monoxide, LCF = latent cancer fatality, MEI = maximally exposed individual, PM₁₀ = particulate matter with a mean diameter of 10 : m or less, ROI = region of influence.

^b These impacts must be added to those for each of the conversion options.

^c For construction, direct jobs and direct income are reported for the peak construction year. For operations, direct jobs and income are presented as annual averages. See Section 5.3.5 for details on indirect impacts in the Paducah site ROI.

^d Land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

TABLE 5.3 Summary of Technologies Considered under Each Conversion Option

Conversion Option	Technologies
Conversion to U_3O_8	Defluorination with anhydrous HF production
	Defluorination with HF neutralization
Conversion to UO_2	Dry process with anhydrous HF production
	Dry process with HF neutralization
	Gelation process
Conversion to metal	Batch metallothermic reduction
	Continuous metallothermic reduction

Following removal of the depleted UF_6 , the emptied cylinders containing “heels” would be stored for about 3 months to allow the level of radioactivity associated with the decay products of uranium that remained after UF_6 withdrawal to decrease to acceptable levels. Subsequently, in the proposed cylinder treatment facility, the emptied cylinders are first washed with water and the resulting aqueous wash solution is evaporated and converted to solid U_3O_8 and HF. The U_3O_8 would be packaged and sent either for disposal or storage. The HF would be neutralized to calcium fluoride (CaF_2) and separately packaged for disposal or sale.

It was assumed that the treated cylinders with a very low residual radiation level would become part of the DOE scrap metal inventory. A report by Nieves et al. (1997) analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle into LLW disposal containers, reuse as LLW containers, free release for remelting, and disposal (i.e., burial) as LLW. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. The estimated total health risks over 20 years of processing ranged from 0.1 to 0.8 total fatality for the various options. The potential health impacts were similar for each of the options; however, the disposal option was considered to have the greatest adverse environmental impacts because it would require land allocations and removal of the metal mass from any further usefulness.

5.2.1 Conversion to U_3O_8

A “dry” process, referred to as defluorination, is well established and currently used by industry. It is also practiced on a large-scale industrial basis by Cogema in France. In this process, UF_6 is chemically decomposed with steam and heat to produce U_3O_8 and concentrated HF. The U_3O_8 would then be compacted to achieve a bulk density of about 3 g/cm³ prior to storage or disposal.

Two technologies were considered for management of the HF following conversion of UF_6 to U_3O_8 . The first process would upgrade the concentrated HF to anhydrous HF for sale. Anhydrous HF is a valuable product; one potential use for HF is in the production of UF_6 from natural uranium ore for feedstock to the gaseous diffusion process. The second process would neutralize the HF to CaF_2 for disposal or sale, depending on whether the CaF_2 with trace amounts of uranium could be marketed.

Because of the considerable market for anhydrous HF, the technology of defluorination with anhydrous HF production would minimize waste and increase product value. However, the handling, storage, and transportation of large quantities of anhydrous HF pose a potential hazard to both workers and the public. During the conversion process, the HF would be upgraded to anhydrous HF by distillation, a common industrial process. Based on historical experience, it is anticipated that the anhydrous HF would contain only trace amounts of depleted uranium (less than 1 ppm, or 0.4 pCi/g) (LLNL 1997). Thus, it was assumed that the anhydrous HF could be sold commercially for unrestricted use.

The process of HF neutralization with lime would convert the concentrated HF to CaF_2 for disposal or possible sale. This step would avoid the potential hazards associated with the processing, general handling, storage, and transportation of large quantities of anhydrous HF. However, the value of CaF_2 is significantly less than that of anhydrous HF, and large quantities of lime are required for neutralization, which would add to the cost of the neutralization option. It is also unknown whether the CaF_2 produced would be sold, disposed of as nonhazardous solid waste, or disposed of as LLW. If disposal were required, there could be moderate impacts to waste management (see Section 5.3.7).

5.2.2 Conversion to UO_2

The conversion of UF_6 to UO_2 is used in the nuclear fuel fabrication industry. The UF_6 is converted to a low-density UO_2 powder by either a “wet” or “dry” process. “Wet” processes are based upon separation of solid UO_2 from an aqueous solution, whereas “dry” processes are based upon decomposing and reducing the UF_6 . The resulting powder is pressed into a pellet under high pressure, and the pellet is sintered (agglomerated) at high temperatures to yield a dense solid. Depending on the shape, size, and size distribution, the bulk density of UO_2 will generally be 6 to 9 g/cm³.

Three technologies were considered for the conversion of UF_6 to UO_2 . A generic industrial dry process with conversion to produce centimeter-sized pellets is the basis for the first two technologies. The first process would upgrade the concentrated HF to anhydrous HF for sale, similar to the U_3O_8 process. The second process would neutralize the HF to CaF_2 for disposal or sale. The third process is a “wet” process, based on pilot-scale studies, and is referred to as the gelation process.

In the dry process, gaseous UF_6 would be chemically reacted with steam to produce solid UO_2F_2 and HF. The UO_2F_2 would then be converted to UO_2 powder through a combination of chemical reactions. Using standard physical treatment operations (milling, compacting, and screening) and the addition of a dry lubricant, the UO_2 powder would be pressed into dense pellets with a bulk density of about 6 g/cm^3 . The HF would be upgraded to anhydrous HF for commercial resale, as described in Section 5.2.1. In the other dry process, the HF would be neutralized to CaF_2 rather than upgraded to anhydrous HF.

In the gelation process, small, dense spheres of UO_2 would be produced through a combination of chemical processes beginning with the conversion of UF_6 to UO_2F_2 and anhydrous HF. The solid UO_2F_2 would then be reacted with steam to produce U_3O_8 and additional anhydrous HF. The U_3O_8 would be dissolved in nitric acid, mixed with other chemicals, and chilled to form a feed broth. This broth would be formed into droplets and fed into a column of hot chlorinated hydrocarbon liquid. Once these droplets formed into spheres, they would be removed from the hot liquid and washed. The droplets would then be dried and converted by heating to dense uranium oxide. The final sintered uranium dioxide spheres are expected to have a density of about 95% or greater of the theoretical maximum density of uranium dioxide, resulting in a bulk density of about 9 g/cm^3 . The gelation process has not been demonstrated on a commercial scale.

5.2.3 Conversion to Metal

The conversion of UF_6 to uranium metal would use a commercial process called metallothermal reduction. During this process, UF_6 would react with both hydrogen and magnesium metal to produce uranium metal, anhydrous HF, and magnesium fluoride (MgF_2 ; slag). Two technologies were considered: a batch reduction process, which is the method used to date, and a continuous reduction process, which is under development and has not been demonstrated on a commercial scale.

In the batch metallothermal reduction process, the UF_6 would be mixed with hydrogen gas in a vertical reaction vessel to form UF_4 and HF. The anhydrous HF would be recovered and stored for sale. The UF_4 powder and an excess of magnesium would be contained in a sealed metal vessel and preheated. Once initiated, the reaction would produce molten uranium metal (collecting at the bottom of the reactor) and less dense molten MgF_2 slag. The cycle time per batch (about 12 hours total) would be dominated by the heating and cooling periods. A large number of reactors would be required because of the long cycle time. The slag would be ground, screened, and prepared for disposal. Any metal pellets would be recovered for recycle.

In the continuous metallothermal reduction process, the UF_6 would be mixed with hydrogen gas in a vertical reaction vessel to form UF_4 and HF. The anhydrous HF would be recovered and stored for sale. A mixture of UF_4 , magnesium (Mg), iron (Fe), and salt would be continuously fed into the top of a heated reactor. The more dense molten uranium/iron compound would settle to the bottom of the reactor where it would be continuously withdrawn. The lower density MgF_2 /salt

mixture would float on top and be separately withdrawn. The molten uranium/iron compound would then be cast into ingots or the end-product form if the manufacturing function was integrated into the conversion facility. The molten salt mixture would be cooled and ground and the water-soluble salt dissolved. After evaporation and drying, the salt would be recycled to the reactor. The insoluble MgF_2 would be drummed for disposal. The annual throughput of the continuous metallothermic reduction reactor would be greater than a batch reactor, requiring fewer reactors.

Neutralization of HF to CaF_2 was not explicitly analyzed in the engineering analysis report for the conversion to metal options (LLNL 1997). However, the process could be implemented and would produce approximately one-third as much CaF_2 as would be produced under the conversion to oxide with neutralization options.

5.2.4 Conversion Technologies and Chemical Forms Considered But Not Analyzed in Detail

The conversion technologies analyzed in the engineering analysis report (LLNL 1997) and the PEIS are those with a sufficient technical basis to carry out preconceptual designs. A number of other promising conversion technologies were considered, but, with minor exceptions, these are in the early stages of conceptualization or development. These options are also discussed in the engineering analysis report (LLNL 1997).

For conversion to an oxide form, technologies considered but not analyzed in detail include a molten metal catalyzed process; the Cameco process (patent pending), which uses a different chemical process than steam hydrolysis/pyrolysis; a conversion process that produces a by-product of aluminum trifluoride (AlF_3); and a defluorination process that results in the production of hydrofluorocarbons. For conversion to metal, a plasma dissociation process was considered but not analyzed in detail.

5.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the conversion options, including impacts from construction and facility operations. For each area of impact, a description of the assessment methodology (including models) is provided in Appendix C of the PEIS.

The environmental impacts from the conversion options were evaluated based on the information described in the engineering analysis report (LLNL 1997). The following general assumptions apply to all conversion facility operations:

- All facility designs were based on a single conversion plant sized to process the entire inventory of DOE-generated depleted UF₆ cylinders over a 20-year period (approximately 2,300 cylinders per year). (When USEC-generated cylinders are considered, operations are assumed to continue for an additional 6 years; see Section 5.4).
- The conversion plant was assumed to operate 24 hours per day, 7 days per week, 52 weeks per year, with 20% down-time.
- A “stand-alone” cylinder treatment facility (for empty cylinders) is collocated with the conversion plant.

For each conversion option, the potential environmental impacts are presented as a range within each area of impact. This range is intended to provide a reasonable estimate of the magnitude of impacts, taking into account the uncertainty relative to the specific technologies that would ultimately be selected for conversion.

5.3.1 Human Health — Normal Operations

5.3.1.1 Radiological Impacts

Radiological impacts to involved workers during normal operations at conversion facilities would result primarily from external radiation from the handling of depleted uranium materials. Impacts to noninvolved workers and members of the public would result primarily from trace amounts of uranium compounds released to the environment. Detailed discussions of the methodologies used in radiological impact analysis are provided in Appendix C of the PEIS and in Cheng et al. (1997).

Radiation exposures of the involved workers were estimated on the basis of information on the anticipated worker activities provided in the engineering analysis report (LLNL 1997). The activities covered involved and noninvolved workers combined. Therefore, special attention was given to estimating the number of involved workers, defined as those performing hands-on activities in the conversion facility. Because the exact activities to be carried out by each involved worker were not clear at this stage, estimation of the individual dose to each worker was difficult. As a result, only the collective dose and average individual dose were calculated for the involved workers. Spreadsheets listing the worker activities and the corresponding dose rates can be found on disk 3 of Cheng et al. (1997) under the file name conv-tm.xls.

Noninvolved workers include those who would not perform hands-on activities in the conversion facility and those who currently work at the Paducah site. Because the distribution of the noninvolved workers in the conversion facility is not known, an even distribution between 100 and 200 m around the center of the site, where the conversion facility was assumed to be constructed, was assumed. Workers that currently work at the Paducah site within 100 m from the center were assumed to be relocated to the outer annulus of 100 to 200 m. Locations of the remaining workers at the Paducah site were assumed to remain unchanged. The on-site worker distribution before addition of the noninvolved workers from the conversion facility can be found on disk 1 of Cheng et al. (1997) under the file name pop-wrk.xls.

To estimate airborne concentrations of uranium at different locations, data on radionuclide emissions from the exhaust stack (LLNL 1997) and site-specific weather data (wind direction and joint frequency) were used. This information was input to the GENII computer code to obtain air concentrations of uranium at different locations and to find the location of the MEI. The weather data used in the analyses can be found on disk 1 of Cheng et al. (1997) under the file name weather.xls.

Collective exposure of the off-site public was also estimated by considering airborne emissions of uranium from the exhaust stack. Distributions of the off-site population used in the estimate can be found on disk 1 of Cheng et al. (1997) under the file name Pop-off.xls. For the MEI, in addition to the exposure resulting from the stack emission, potential exposure resulting from discharge of liquid effluent was also considered. The discharge of liquid effluent could contaminate a nearby river, which was assumed to be the drinking water source for the MEI. Concentrations of uranium in the surface water were obtained from Tomasko (1997b). The estimated range can be found on disk 1 of Cheng et al. (1997) under the file name Wtimpact.xls.

Estimated potential impacts to the MEI and the entire population for the noninvolved workers and the off-site public resulting from airborne emission of radionuclides can be found on disk 1 of Cheng et al. (1997) under the file name Airimpct.xls.

5.3.1.1.1 Conversion to U_3O_8

Conversion to U_3O_8 would result in average radiation exposure of about 300 mrem/yr to involved workers and less than 0.005 mrem/yr to noninvolved workers and members of the public. Radiation doses and cancer risks associated with normal operations of the U_3O_8 conversion facilities are listed in Tables 5.4 and 5.5, respectively. The two conversion technologies evaluated are described in Section 5.2.1. Due to the similarity of the conversion processes, the airborne emission rates of uranium compounds and the material handling activities are expected to vary only slightly from each other, resulting in similar radiological impacts.

Involved Workers. Radiation exposures for the involved workers are estimated on the basis of the descriptions of material handling activities provided in the engineering analysis report

TABLE 5.4 Radiological Doses from Conversion/Treatment Options under Normal Operations at the Paducah Site^a

Option	Dose to Receptor					
	Involved Workers ^b		Noninvolved Workers ^c		General Public	
	Average Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose ^d (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose ^e (mrem/yr)	Collective Dose ^f (person-rem/yr)
Conversion to U ₃ O ₈	300	41	1.6×10^{-3}	2.1×10^{-3}	4.9×10^{-3}	4.3×10^{-2}
Conversion to UO ₂	180 – 340	49 – 54	3.2×10^{-3} to 6.1×10^{-3}	4.2×10^{-3} to 8.1×10^{-3}	9.7×10^{-3} to 1.9×10^{-2}	8.5×10^{-2} to 1.6×10^{-1}
Conversion to metal	230 – 240	33 – 67	6.8×10^{-4} to 4.8×10^{-3}	9.0×10^{-4} to 6.3×10^{-3}	2.1×10^{-3} to 1.5×10^{-2}	1.8×10^{-2} to 1.3×10^{-1}
Cylinder treatment	160	16	4.9×10^{-6}	6.5×10^{-6}	1.5×10^{-5}	1.3×10^{-4}

^a Impacts are reported as ranges, which result from the different conversion technologies within each option using environmental parameters for the Paducah site as representative parameters.

^b Involved workers are those workers directly involved with the handling of radioactive materials. Calculation results are presented as average individual dose and collective dose for the worker population. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

^c Noninvolved workers include individuals who work at the facility but are not directly involved in handling materials and individuals who work on-site but not within the facility. The population size of noninvolved workers is about 2,000.

^d The MEI for the noninvolved workers was assumed to be located on-site 100 m or more from the release point at the location that would result in the largest dose, which includes doses from inhalation, external radiation, and incidental soil ingestion.

^e The MEI for the general public was assumed to be located off-site at the point that would result in the largest dose from exposures through inhalation, external radiation, and ingestion of plant foods, meat, milk, soil, and drinking water.

^f Collective dose was estimated for the population (about 500,000 persons) within a radius of 50 miles (80 km) around the Paducah site. The exposure pathways considered are inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil.

TABLE 5.5 Latent Cancer Risks from Conversion/Treatment Options under Normal Operations at the Paducah Site^a

Option	Latent Cancer Risk to Receptor					
	Involved Workers ^b		Noninvolved Workers ^c		General Public	
	Average Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk ^d (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk ^e (risk/yr)	Collective Risk ^f (fatalities/yr)
Conversion to U ₃ O ₈	1×10^{-4}	2×10^{-2}	6×10^{-10}	9×10^{-7}	2×10^{-9}	2×10^{-5}
Conversion to UO ₂	7×10^{-5} to 1×10^{-4}	2×10^{-2}	1×10^{-9} to 2×10^{-9}	2×10^{-6} to 3×10^{-6}	5×10^{-9} to 9×10^{-9}	4×10^{-5} to 8×10^{-5}
Conversion to metal	9×10^{-5} to 1×10^{-4}	1×10^{-2} to 3×10^{-2}	3×10^{-10} to 2×10^{-9}	4×10^{-7} to 3×10^{-6}	1×10^{-9} to 7×10^{-9}	9×10^{-6} to 6×10^{-5}
Cylinder treatment	6×10^{-5}	6×10^{-3}	2×10^{-12}	3×10^{-9}	8×10^{-12}	6×10^{-8}

^a Impacts are reported as ranges, which result from the different conversion technologies within each option.

^b Involved workers are those workers directly involved with the handling of radioactive materials. Calculation results are presented as average individual risk and collective risk for the worker population.

^c Noninvolved workers include individuals who work at the facility but are not directly involved in handling materials and individuals who work on-site but not within the facility. The population size of noninvolved workers is about 2,000.

^d The MEI for the noninvolved workers was assumed to be located on-site 100 m or more from the release point that would result in the largest risk, which includes risks from inhalation, external radiation, and incidental soil ingestion.

^e The MEI for the general public was assumed to be located off-site at the point that would result in the largest risk from exposures through inhalation, external radiation, and ingestion of plant foods, meat, milk, soil, and drinking water.

^f Collective risk was estimated for the population (approximately 500,000 persons) within a radius of 50 miles (80 km) around the Paducah site. The exposure pathways considered are inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil.

(LLNL 1997). Because of the preliminary nature of each facility design, the estimated radiation doses are subject to a large degree of uncertainty. The results presented here should be used only for comparing different technologies. Radiation exposure of involved workers would be monitored by a dosimetry program and maintained below regulatory limits.

The collective dose for involved workers is estimated to be about 41 person-rem/yr for 135 workers for the U_3O_8 conversion processes. This would result in about 0.02 excess LCFs per year (or about 2 LCFs over a 100-year period) among the involved workers. If evenly distributed among involved workers, the average individual dose would be approximately 300 mrem/yr, well below the regulatory limit of 5,000 mrem/yr for workers (10 CFR Part 835). This corresponds to an average cancer risk of about 1×10^{-4} per year (1 chance in 10,000 of developing 1 LCF per year).

Noninvolved Workers. Estimated doses and health risks are much lower for noninvolved workers than for involved workers. Inhalation of U_3O_8 particulates accounts for more than 99.9% of the radiological exposures for noninvolved workers. The radiation dose (risk of an LCF) to a maximally exposed noninvolved worker would be approximately 1.6×10^{-3} mrem/yr (6×10^{-10} per year), which is a very small fraction (less than 1 in 6,000) of the maximally allowable dose limit (10 mrem/yr) from airborne emissions (40 CFR Part 61). The population of noninvolved workers would be about 2,000. The resulting collective dose would be about 0.0021 person-rem/yr.

General Public. The locations of the MEI for the general public are either at or near the site boundary. Although other exposure pathways are also considered, inhalation exposure accounts for more than 95% of the total dose. The radiation dose for the MEI would be negligible, approximately 0.0049 mrem/yr, compared with the dose limit of 10 mrem/yr from airborne emissions. The potential radiation dose resulting from drinking contaminated surface water would be two orders of magnitude less than that from exposure to airborne emissions.

For a population of about 500,000 persons within a 50-mile (80-km) distance from the site boundary, the collective dose would be about 0.0043 person-rem/yr, which corresponds to about 2×10^{-5} LCF per year (about 1 chance in 50,000 of 1 LCF per year in the population).

5.3.1.1.2 Conversion to UO_2

Conversion to UO_2 would result in average radiation exposure of less than 340 mrem/yr to involved workers and less than 0.02 mrem/yr to noninvolved workers and members of the public, similar to those for conversion to U_3O_8 . The radiation doses and cancer risks associated with normal operations of the UO_2 conversion facilities are listed in Tables 5.4 and 5.5, respectively.

Involved Workers. The estimated collective dose for involved workers ranges from 49 to 54 person-rem/yr, slightly greater than conversion to U_3O_8 . This would result in approximately 0.02 excess cancer fatality per year (2 LCFs over a 100-year period). If evenly distributed among involved workers (about 160 to 270 workers), the average individual dose would range from about 180 to 340 mrem/yr, well below the annual worker dose limit of 5,000 mrem/yr. This corresponds to an average cancer risk of 7×10^{-5} to 1×10^{-4} per year (less than 1 chance in 10,000 of developing 1 LCF per year).

Noninvolved Workers. The doses to noninvolved workers are higher than those for conversion to U_3O_8 . The dose to the MEI would range from 0.0032 to 0.006 mrem/yr, which is negligible compared with the dose limit of 10 mrem/yr for airborne emissions. For a representative population size of about 2,000, the collective dose would range from 0.0042 to 0.0081 person-rem/yr. The estimated number of potential LCFs would be less than 0.00001 per year.

General Public. The estimated radiation dose to the MEI for the general public would be higher than that from conversion to U_3O_8 , ranging from 0.0097 to 0.019 mrem/yr. These values are well below the radiation dose limit of 10 mrem/yr set for airborne emissions. The radiation dose from drinking contaminated surface water would be very small compared with the dose from airborne emissions. The collective dose for a population of about 500,000 persons would range from 0.085 to 0.16 person-rem/yr. This would correspond to 4×10^{-5} to 8×10^{-5} CF per year among the population (less than 1 chance in 10,000 of 1 LCF per year).

5.3.1.1.3 Conversion to Metal

Conversion to uranium metal would result in average exposure of less than 240 mrem/yr to involved workers and less than 0.03 mrem/yr to noninvolved workers and members of the public. The radiological impacts and cancer risks from operations of the metal conversion facilities are shown in Tables 5.4 and 5.5, respectively.

Involved Workers. The collective dose to involved workers would range from 33 to 67 person-rem/yr, similar to conversion to U_3O_8 and conversion to UO_2 . The corresponding number of LCFs would range from 0.01 to 0.03 per year (1 to 3 LCFs over a 100-year period) among a worker population of approximately 140 to 270. If evenly distributed among workers, the average annual worker dose would be about 240 mrem/yr, which is well below the regulatory limit of 5,000 mrem/yr. The corresponding cancer risk is 0.0001 per year (less than 1 chance in 10,000 of developing 1 LCF per year).

Noninvolved Workers. The radiation dose to noninvolved workers would be similar to those for conversion to U_3O_8 and conversion to UO_2 and would be negligible compared with the regulatory dose limit of 10 mrem/yr. The collective dose would range from 0.0009 to 0.0063 person-rem/yr for about 2,000 workers.

General Public. The radiation dose for the MEI of the general public would range from 0.0021 to 0.015 mrem/yr, which corresponds to a cancer risk of 1 to 7×10^{-9} per year (less than 1 chance in 100 million of developing 1 LCF per year). The radiation dose from drinking contaminated surface water would be very small compared with the dose from airborne emissions. The collective dose for the population of about 500,000 people living within 50 miles (80 km) of the site would range from 0.018 to 0.13 person-rem/yr. This corresponds to about 9×10^{-6} to 6×10^{-5} LCF per year within the exposed population.

5.3.1.1.4 Cylinder Treatment Facility

The empty UF_6 cylinders from the conversion facilities would be decontaminated at a cylinder treatment facility before reuse or final disposal. Average radiological exposure incurred by involved workers would be less than 200 mrem/yr, and maximum exposures incurred by noninvolved workers and the off-site public would be less than 1.5×10^{-5} mrem/yr. The estimated radiological impacts and cancer risks from cylinder treatment operations are presented in Tables 5.4 and 5.5, respectively.

Involved Workers. The average annual dose received by involved workers would be approximately 160 mrem/yr, which was calculated by evenly distributing the estimated collective dose of 16 person-rem/yr to a worker population of approximately 100. The average dose is a small fraction of the dose limit of 5,000 mrem/yr and corresponds to a cancer risk of 6×10^{-5} per year (1 chance in 16,000 of developing 1 LCF per year). The collective number of LCFs among the involved workers would be 6×10^{-3} per year.

Noninvolved Workers. Only a small amount of U_3O_8 (0.01 lb/yr) would be released to the atmosphere from the cylinder treatment facility. Radiological exposure to the noninvolved worker MEI would be negligible (approximately 4.9×10^{-6} mrem/yr). The collective dose would be approximately 6.5×10^{-6} person-rem/yr for a population of 2,000.

General Public. The radiation exposure of the general public MEI from normal operations at the treatment facility would be negligible (about 1.5×10^{-5} mrem/yr). The collective dose to the off-site population of 500,000 people would be less than 1.3×10^{-4} person-rem/yr.

5.3.1.2 Chemical Impacts

Potential chemical impacts to human health from normal operations at the conversion facility would result primarily from exposure to trace amounts of insoluble uranium compounds (i.e., UO_2 , U_3O_8 , and UF_4) and HF released from process exhaust stacks. Risks from normal operations were quantified on the basis of calculated hazard indices. Information on the exposure assumptions, health effects assumptions, reference doses used for uranium compounds and HF, and calculational methods used in the chemical impact analysis are provided in Appendix C of the PEIS and Cheng et al. (1997).

Conversion to U_3O_8 , UO_2 , or metal would result in very low-level exposures to hazardous chemicals. No adverse health effects would be expected during normal operations. Hazardous chemical human health impacts resulting from normal operations of the conversion facilities are summarized in Table 5.6. The hazard indices for all conversion processes are more than 5,000 times lower than the hazard index of 1, which is the level at which adverse health effects might be expected to occur in some exposed individuals. The range of chemical exposures to the noninvolved workers and general public results from the different conversion technologies assessed.

One of the UO_2 conversion options, the gelation process, would also generate emissions of the chemical trichloroethylene from the process stack. The estimated increased lifetime carcinogenic risk of cancer incidence for noninvolved workers and members of the general public from exposure to trichloroethylene would be less than 1×10^{-8} , a very small increased risk that would not be considered an adverse impact.

The empty UF_6 cylinders from the conversion facilities would be decontaminated at a cylinder treatment facility before being added to the DOE scrap metal inventory. Estimates of the hazardous chemical impacts to human health resulting from cylinder treatment operations are also summarized in Table 5.6. The hazard indices from the cylinder treatment facility would be hundreds of times lower than those predicted for the conversion options, for which no adverse human health impacts were predicted.

5.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum from high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table 5.7. The following sections present the results for radiological and chemical health impacts of the highest-consequence accident in each frequency category using the Paducah site as representative. Results for all accidents listed in Table 5.7 are presented in Policastro et al. (1997). A detailed description of the methodology and assumptions used in the calculations is also provided in Appendix C of the PEIS and Policastro et al. (1997).

TABLE 5.6 Chemical Impacts to Human Health for Conversion/Treatment Options under Normal Operations at the Paducah Site^a

Option	Impacts to Receptor			
	Noninvolved Workers ^b		General Public	
	Hazard Index for MEI ^{c,d}	Population Risk ^e (persons at risk/yr)	Hazard Index for MEI ^{c,f}	Population Risk ^e (persons at risk/yr)
Conversion to U ₃ O ₈	3.9×10^{-7} to 8.0×10^{-7}	—	3.4×10^{-5} to 7.1×10^{-5}	—
Conversion to UO ₂	7.5×10^{-7} to 1.2×10^{-6}	—	6.6×10^{-5} to 1.1×10^{-4}	—
Conversion to metal	4.7×10^{-7} to 9.6×10^{-7}	—	4.1×10^{-5} to 8.2×10^{-5}	—
Cylinder treatment	1.5×10^{-9}	—	7.0×10^{-8}	—

^a Impacts are reported as ranges, which result from variations in the different conversion technologies within each option.

^b Noninvolved workers include individuals who work at the facility but are not directly involved in handling hazardous materials and individuals who work on-site but not within the facility.

^c The hazard index is an indicator for potential adverse health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation. Hazard indices were calculated for combined exposures to uranium compounds and HF.

^d The MEI for the noninvolved workers was assumed to be located on-site 100 m or more from the release point at the location that would result in the largest exposure from airborne emissions, including inhalation and incidental ingestion of contaminated soil.

^e Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

^f The MEI for the general public was assumed to be located off-site at the location that would result in the largest exposures through inhalation and ingestion of soil and drinking water.

TABLE 5.7 Accidents Considered for the Conversion Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Conversion to U₃O₈					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the dry ground.	UF ₆	24	60 (continuous)	Ground
Cylinder valve shear	A single UF ₆ cylinder is mishandled, etc., resulting in the shearing of the cylinder valve and loss of solid UF ₆ from the valve onto the ground.	UF ₆	0.25	120 (continuous)	Ground
HF system leak during upgrading of HF to anhydrous HF	An HF absorber column line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	216	15	Stack
HF system leak during HF neutralization	An HF distillation column line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	10	15	Stack
Loss of cooling water during upgrading of HF to anhydrous HF	Cooling water is lost to the HF distillation column condenser, and HF vapor is removed by a limestone bed before reaching the environment.	HF	22	2	Stack
Loss of cooling water during HF neutralization	Cooling water is lost to the absorption column coolers, and HF vapor is released to the atmosphere.	HF	19	2	Stack
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA ^b	NA	NA
U ₃ O ₈ drum spill	A single U ₃ O ₈ drum is damaged by a forklift and spills its contents onto the floor inside the storage facility.	U ₃ O ₈	0.00014	30	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Ammonia release	An ammonia fill line is momentarily disconnected, and ammonia is released at grade.	Ammonia	255	1	Ground
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the wet ground.	HF	96	60 (continuous)	Ground
HF pipeline rupture	An earthquake ruptures an underground pipeline transporting HF _s , releasing it to the ground.	HF	500	10	Soil
HF storage tank overflow	An HF storage tank overflows during filling, spilling onto the floor; the pool of HF evaporates and is released through the building stack.	HF	45	15	Stack

TABLE 5.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Conversion to U₃O₈ (Cont.)					
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area into a 0.25-in.-deep water pool.	HF	150	60 (continuous)	Ground
Earthquake	The U ₃ O ₈ storage building is damaged during a design-basis earthquake, and 10% of the stored drums are breached.	U ₃ O ₈	41	30	Ground
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the conversion reactor ignites and causes the reactor to rupture.	U ₃ O ₈ HF	0.27 7	30	Stack
Tornado	A windblown missile from a design-basis tornado pierces a single U ₃ O ₈ drum in the U ₃ O ₈ storage building.	U ₃ O ₈	69	0.5	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Anhydrous HF tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled anhydrous HF storage tank.	HF	7,920	120	Ground
Ammonia tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled ammonia storage tank.	Ammonia	118,000	20	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	4,240 1,190	0 to 30 30 to 121	Ground

TABLE 5.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Conversion to UO₂					
Likely Accidents (frequency: 1 or more times in 100 years)					
Ammonia stripper overpressure	Cooling water is lost to the ammonia stripping column, and ammonia vapor is released to the atmosphere.	Ammonia	15	1	Ground
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the dry ground.	UF ₆	24	60 (continuous)	Ground
Cylinder valve shear	A single UF ₆ cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF ₆ from the valve onto the ground.	UF ₆	0.25	120 (continuous)	Ground
HF system leak during upgrading of HF to anhydrous HF	An HF absorber line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	216	15	Stack
HF system leak during HF neutralization	An HF distillation column line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	10	15	Stack
Loss of cooling water during upgrading of HF to anhydrous HF	Cooling water is lost to the HF distillation column condenser, and HF vapor is removed by a limestone bed before reaching the environment.	HF	22	2	Stack
Loss of cooling water during HF neutralization	Cooling water is lost to the absorption column coolers, and HF vapor is released to the atmosphere.	HF	19	2	Stack
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
Trichloroethylene (TCE) spill	A TCE storage tank spills onto the floor during operations, and the pool of TCE evaporates and is released to the environment.	TCE	120	120	Stack
Trichloroethylene vapor leak	The exhaust line from the gel sphere dryers leaks 5% of its flowing contents due to potential pipe leakage.	TCE	20	60	Stack
UO ₂ drum spill	A single UO ₂ drum is damaged by a forklift and spills its contents onto the floor inside the storage facility.	UO ₂	0.000056	30	Stack

TABLE 5.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Conversion to UO₂ (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Ammonia release	An ammonia fill line is momentarily disconnected, and ammonia is released at grade.	Ammonia	255	1	Ground
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the wet ground.	HF	96	60 (continuous)	Ground
HF pipeline rupture	An earthquake ruptures an underground pipeline transporting HF, releasing it to the ground.	HF	500	10	Soil
HF storage tank overflow	An HF storage tank overflows during filling, spilling onto the floor; the pool of HF evaporates and is released to the indoor air of the process building.	HF	45	15	Stack
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area into a 0.25-in.-deep water pool.	HF	147	60 (continuous)	Ground
Earthquake	The UO ₂ storage building is damaged during a design-basis earthquake, and 10% of the stored drums are breached.	UO ₂	9.8	30	Ground
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the ceramic UO ₂ conversion reactor ignites and causes the reactor to rupture.	UO ₂ HF	0.25 7	30	Stack
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the gelation conversion reactor ignites and causes the reactor to rupture.	UO ₂	0.017	30	Stack
Tornado	A windblown missile from a design-basis tornado pierces a single ceramic UO ₂ drum in the UO ₂ storage building.	UO ₂	3.7	0.5	Ground
Tornado	A windblown missile from a design-basis tornado pierces a single UO ₂ drum produced by gelation in the UO ₂ storage building.	UO ₂	5.6	0.5	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground

TABLE 5.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Conversion to UO₂ (Cont.)					
Incredible Accidents (frequency: less than 1 in 1 million years)					
Anhydrous HF tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled anhydrous HF storage tank.	HF	7,920	120	Ground
Ammonia tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled ammonia storage tank.	Ammonia	117,920	20	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0	0 to 12	Ground
			3,840	12	
			2,980	12 to 30	
			1,190	30 to 121	
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	4,240	0 to 30	Ground
			1,190	30 to 121	
<hr/>					
Conversion to Metal					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the dry ground.	UF ₆	24	60 (continuous)	Ground
Cylinder valve shear	A single UF ₆ cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF ₆ from the valve onto the ground.	UF ₆	0.25	120 (continuous)	Ground
HF system leak	An off-gas line from the conversion reactor to the condenser leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	3.6	15	Stack
Loss of cooling water	Cooling water is lost to the reactor HF coolers, and HF vapor is released to the atmosphere.	HF	17	2	Stack
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
UF ₄ drum spill	A single UF ₄ drum is damaged by a forklift and spills its contents onto the floor of the process building.	UF ₄	0.00015	30	Stack

TABLE 5.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Conversion to Metal (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Ammonia release	An ammonia fill line is momentarily disconnected, and ammonia is released at grade.	Ammonia	255	1	Ground
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the wet ground.	HF	96	60 (continuous)	Ground
HF pipeline rupture	An earthquake ruptures an underground pipeline transporting HF and releasing it to the ground.	HF	500	10	Soil
HF storage tank overflow	An HF storage tank overflows during filling, spilling onto the floor; the pool of HF evaporates and is released to the indoor air of the process building.	HF	45	15	Stack
Nitric acid (HNO ₃) release	Due to equipment failure, hot HNO ₃ flows through a relief valve.	HNO ₃	6	2	Stack
Uranium metal fire	The wooden boxes containing the uranium metal product burn, affecting a total of 34 uranium derbies.	U ₃ O ₈	0.058	30	Stack
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area into a 0.25-in.-deep water pool.	HF	147	60 (continuous)	Ground
Earthquake	The uranium product storage building is damaged during a design-basis earthquake, and some of the boxes containing uranium metal are breached.	U ₃ O ₈	0.058	30	Ground
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the conversion reactor ignites and causes the reactor to rupture.	UF ₄ HF	0.05 2	30	Stack
Reactor rupture	A reactor containing molten uranium metal is damaged or breached, releasing hot molten uranium metal as airborne particles.	U ₃ O ₈	0.0026	15	Stack
Tornado	A design-basis tornado does not result in significant releases because uranium is in metal form.	No release	NA	NA	NA
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground

TABLE 5.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Conversion to Metal (Cont.)					
Incredible Accidents (frequency: less than 1 in 1 million years)					
Anhydrous HF tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled anhydrous HF storage tank.	HF	7,920	120	Ground
Ammonia tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled ammonia storage tank.	Ammonia	118,000	20	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0	0 to 12	Ground
			3,840	12	
			2,980	12 to 30	
			1,190	30 to 121	
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	4,240	0 to 30	Ground
			1,190	30 to 121	
Cylinder Treatment Facility					
Likely Accidents (frequency: 1 or more times in 100 years)					
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
U ₃ O ₈ drum spill	A single U ₃ O ₈ drum is damaged by a forklift and spills its contents onto the ground outside the storage facility.	U ₃ O ₈	0.138	30	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Loss of scrubber water	Water is lost to both HF scrubbers, and HF is released with the off gas.	HF	26	30	Stack
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Depleted UF ₆ cylinder rupture	A truck crashes into the depleted UF ₆ heel storage pad, damaging two cylinders; the fuel from the truck ignites and releases all of the depleted UF ₆ .	UO ₂ F ₂ HF	38.5 10	30	Ground
Earthquake	The solids product building is damaged during a design-basis earthquake, and 50% of the stored drums are breached.	U ₃ O ₈	1.9	30	Ground
HF aqueous tank rupture	The evaporator tank fails, releasing its entire contents of HF to the floor; the pool of aqueous HF evaporates and is released to the indoor air of the process building.	HF	3.4	60	Stack
Tornado	A windblown missile from a design-basis tornado pierces a single U ₃ O ₈ drum in the solids product building.	U ₃ O ₈	69	0.5	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA

^a Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

^b NA = not applicable.

5.3.2.1 Radiological Impacts

Table 5.8 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table 5.9. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions, and two or three technologies were considered for each conversion option. The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence of between 1 in 10,000 and 1 in 1 million per year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.
- The maximum radiological dose to noninvolved worker and general public MEIs (assuming that an accident occurred) would be 9.2 rem. This dose is less than the 25-rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the NRC (1994).
- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table 5.9] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the conversion facility accidents.

5.3.2.2 Chemical Impacts

The accidents considered in this section are listed in Table 5.7. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables 5.10 and 5.11. The results are presented as (1) number of people with potential for adverse effects and (2) number of people with potential for irreversible adverse effects. The tables present the results for the accident within each frequency category that would affect the largest number of people (total of workers and off-site population) (Policastro et al. 1997). The numbers of noninvolved workers and members of the off-site public represent the impacts if the associated accident was assumed to occur. The accidents listed in Tables 5.10 and 5.11 are not identical because an accident with the largest impacts for adverse effects might not lead to the largest impacts for irreversible adverse effects. The impacts may be summarized as follows:

- If the accidents identified in Tables 5.10 and 5.11 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 19,000 (maximum corresponding to HF tank rupture), and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 1,700 (maximum corresponding to ammonia tank rupture).

TABLE 5.8 Estimated Radiological Doses per Accident Occurrence for the Conversion Options for the Paducah Site^a

Option/Accident ^b	Frequency Category ^c	Maximum Dose				Minimum Dose			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Conversion to U₃O₈									
Corroded cylinder spill, dry conditions	L	7.7 × 10 ⁻²	3.2	2.3 × 10 ⁻³	6.1 × 10 ⁻²	3.3 × 10 ⁻³	1.3 × 10 ⁻¹	9.8 × 10 ⁻⁵	7.4 × 10 ⁻³
Earthquake	EU	9.2	3.8 × 10 ²	2.7 × 10 ⁻¹	5.3	3.9 × 10 ⁻¹	15	1.2 × 10 ⁻²	8.0 × 10 ⁻¹
Small plane crash, 2 full 48G cylinders	I	6.6 × 10 ⁻³	1.8	4.9 × 10 ⁻³	2.1 × 10 ⁻¹	8.7 × 10 ⁻⁴	2.2 × 10 ⁻¹	6.2 × 10 ⁻⁴	3.0 × 10 ⁻²
Conversion to UO₂									
Corroded cylinder spill, dry conditions	L	7.7 × 10 ⁻²	3.2	2.3 × 10 ⁻³	6.1 × 10 ⁻²	3.3 × 10 ⁻³	1.3 × 10 ⁻¹	9.8 × 10 ⁻⁵	7.4 × 10 ⁻³
Earthquake	EU	2.3	94	6.8 × 10 ⁻²	1.3	9.6 × 10 ⁻²	3.7	2.9 × 10 ⁻³	2.0 × 10 ⁻¹
Small plane crash, 2 full 48G cylinders	I	6.6 × 10 ⁻³	1.8	4.9 × 10 ⁻³	2.1 × 10 ⁻¹	8.7 × 10 ⁻⁴	2.2 × 10 ⁻¹	6.2 × 10 ⁻⁴	3.0 × 10 ⁻²
Conversion to metal									
Corroded cylinder spill, dry conditions	L	7.7 × 10 ⁻²	3.2	2.3 × 10 ⁻³	6.1 × 10 ⁻²	3.3 × 10 ⁻³	1.3 × 10 ⁻¹	9.8 × 10 ⁻⁵	7.4 × 10 ⁻³
Uranium metal fire	U	2.4 × 10 ⁻⁶	4.0 × 10 ⁻⁴	2.6 × 10 ⁻⁶	2.4 × 10 ⁻³	4.9 × 10 ⁻⁷	6.1 × 10 ⁻⁶	2.0 × 10 ⁻⁶	1.1 × 10 ⁻³
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0 × 10 ⁻²	5.3	1.5 × 10 ⁻²	9.0	3.7 × 10 ⁻³	5.2 × 10 ⁻¹	1.9 × 10 ⁻³	6.3 × 10 ⁻¹
Small plane crash, 2 full 48G cylinders	I	6.6 × 10 ⁻³	1.8	4.9 × 10 ⁻³	2.1 × 10 ⁻¹	8.7 × 10 ⁻⁴	2.2 × 10 ⁻¹	6.2 × 10 ⁻⁴	3.0 × 10 ⁻²
Cylinder treatment									
U ₃ O ₈ drum spill	L	3.1 × 10 ⁻²	1.3	9.2 × 10 ⁻⁴	1.8 × 10 ⁻²	1.3 × 10 ⁻³	5.1 × 10 ⁻²	3.9 × 10 ⁻⁵	2.7 × 10 ⁻³
Tornado ^d	EU	4.3 × 10 ⁻¹	1.7 × 10 ¹	1.3 × 10 ⁻²	4.5 × 10 ⁻¹	4.3 × 10 ⁻¹	1.7 × 10 ¹	1.3 × 10 ⁻²	4.5 × 10 ⁻¹

^a Maximum and minimum doses reflect differences in assumed technologies and meteorological conditions at the time of the accident, assumed to occur at the center of the Paducah site. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

^b The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

TABLE 5.9 Estimated Radiological Health Risks per Accident Occurrence for the Conversion Options for the Paducah Site^a

Option/Accident ^b	Frequency Category ^c	Maximum Risk ^d (LCFs)				Minimum Risk ^d (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Conversion to U₃O₈									
Corroded cylinder spill, dry conditions	L	3 × 10 ⁻⁵	1 × 10 ⁻³	1 × 10 ⁻⁶	3 × 10 ⁻⁵	1 × 10 ⁻⁶	5 × 10 ⁻⁵	5 × 10 ⁻⁸	4 × 10 ⁻⁶
Earthquake	EU	4 × 10 ⁻³	2 × 10 ⁻¹	1 × 10 ⁻⁴	3 × 10 ⁻³	2 × 10 ⁻⁴	6 × 10 ⁻³	6 × 10 ⁻⁶	4 × 10 ⁻⁴
Small plane crash, 2 full 48G cylinders	I	3 × 10 ⁻⁶	7 × 10 ⁻⁴	2 × 10 ⁻⁶	1 × 10 ⁻⁴	3 × 10 ⁻⁷	9 × 10 ⁻⁵	3 × 10 ⁻⁷	1 × 10 ⁻⁵
Conversion to UO₂									
Corroded cylinder spill, dry conditions	L	3 × 10 ⁻⁵	1 × 10 ⁻³	1 × 10 ⁻⁶	3 × 10 ⁻⁵	1 × 10 ⁻⁶	5 × 10 ⁻⁵	5 × 10 ⁻⁸	4 × 10 ⁻⁶
Earthquake	EU	9 × 10 ⁻⁴	4 × 10 ⁻²	3 × 10 ⁻⁵	7 × 10 ⁻⁴	4 × 10 ⁻⁵	1 × 10 ⁻³	1 × 10 ⁻⁶	1 × 10 ⁻⁴
Small plane crash, 2 full 48G cylinders	I	3 × 10 ⁻⁶	7 × 10 ⁻⁴	2 × 10 ⁻⁶	1 × 10 ⁻⁴	3 × 10 ⁻⁷	9 × 10 ⁻⁵	3 × 10 ⁻⁷	1 × 10 ⁻⁵
Conversion to metal									
Corroded cylinder spill, dry conditions	L	3 × 10 ⁻⁵	1 × 10 ⁻³	1 × 10 ⁻⁶	3 × 10 ⁻⁵	1 × 10 ⁻⁶	5 × 10 ⁻⁵	5 × 10 ⁻⁸	4 × 10 ⁻⁶
Uranium metal fire	U	1 × 10 ⁻⁹	2 × 10 ⁻⁷	1 × 10 ⁻⁹	1 × 10 ⁻⁶	2 × 10 ⁻¹⁰	2 × 10 ⁻⁹	1 × 10 ⁻⁹	6 × 10 ⁻⁷
Vehicle-induced fire, 3 full 48G cylinders	EU	8 × 10 ⁻⁶	2 × 10 ⁻³	7 × 10 ⁻⁶	5 × 10 ⁻³	1 × 10 ⁻⁶	2 × 10 ⁻⁴	1 × 10 ⁻⁶	3 × 10 ⁻⁴
Small plane crash, 2 full 48G cylinders	I	3 × 10 ⁻⁶	7 × 10 ⁻⁴	2 × 10 ⁻⁶	1 × 10 ⁻⁴	3 × 10 ⁻⁷	9 × 10 ⁻⁵	3 × 10 ⁻⁷	1 × 10 ⁻⁵
Cylinder treatment									
U ₃ O ₈ drum spill	L	1 × 10 ⁻⁵	5 × 10 ⁻⁴	5 × 10 ⁻⁷	9 × 10 ⁻⁶	5 × 10 ⁻⁷	2 × 10 ⁻⁵	2 × 10 ⁻⁸	1 × 10 ⁻⁶
Tornado ^d	EU	2 × 10 ⁻⁴	7 × 10 ⁻³	7 × 10 ⁻⁶	2 × 10 ⁻⁴	2 × 10 ⁻⁴	7 × 10 ⁻³	7 × 10 ⁻⁶	2 × 10 ⁻⁴

^a Maximum and minimum risks reflect differences in assumed technologies and meteorological conditions at the time of the accident, assumed to occur at the center of the Paducah site. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed. Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCFs) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one that would result in the highest risks to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

TABLE 5.10 Number of Persons with Potential for Adverse Effects from Accidents under the Conversion Options for the Paducah Site^a

Option/Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
Conversion to U₃O₈									
Corroded cylinder spill, dry conditions	L	Yes	120	No	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	450	Yes	10	Yes _f	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes _f	0	Yes	3
HF tank rupture	I	Yes	770	Yes	19,000	Yes	770	Yes	18
Conversion to UO₂									
Corroded cylinder spill, dry conditions	L	Yes	120	No	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	450	Yes	10	Yes _f	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes _f	0	Yes	3
HF tank rupture	I	Yes	770	Yes	19,000	Yes	770	Yes	18
Conversion to metal									
Corroded cylinder spill, dry conditions	L	Yes	120	No	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	450	Yes	10	Yes _f	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes _f	0	Yes	3
HF tank rupture	I	Yes	770	Yes	19,000	Yes	770	Yes	18
Cylinder treatment									
U ₃ O ₈ drum spill ^g	L	No	0	No	0	No	0	No	0
Loss of scrubber water ^g	U	No _f	0	No	0	No _f	0	No	0
Tornado ^h	EU	Yes _f	0	No	0	NA ⁱ	NA	NA	NA

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-7}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum values reflect differences in assumed meteorological conditions at the time of the accident, assumed to occur at the center of the site. In general, the maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas the minimum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential adverse effects to an individual.

^f MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the site were used, which did not show receptors at the MEI locations.

^g These accidents would result in the largest plume sizes, although no people would be affected.

^h Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

ⁱ NA = not applicable.

TABLE 5.11 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Conversion Options for the Paducah Site^a

Option/Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
Conversion to U₃O₈									
Corroded cylinder spill, dry conditions	L	Yes	4	No _f	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	250	Yes _f	0	Yes	4	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	330	Yes _f	0	Yes	7	No	0
Ammonia tank rupture	I	Yes	420	Yes	1,700	Yes	180	Yes	8
Conversion to UO₂									
Ammonia stripper overpressure	L	Yes	5	No _f	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	250	Yes _f	0	Yes	4	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	330	Yes _f	0	Yes	7	No	0
Ammonia tank rupture	I	Yes	420	Yes	1,700	Yes	180	Yes	8
Conversion to metal									
Corroded cylinder spill, dry conditions	L	Yes	4	No _f	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	250	Yes _f	0	Yes	4	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	330	Yes _f	0	Yes	7	No	0
Ammonia tank rupture	I	Yes	420	Yes	1,700	Yes	180	Yes	8
Cylinder treatment									
U ₃ O ₈ drum spill ^g	L	No	0	No	0	No	0	No	0
Loss of scrubber water ^g	U	No	0	No	0	No	0	No	0
Tornado ^h	EU	No	0	No	0	NA ⁱ	NA	NA	NA

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum values reflect different meteorological conditions at the time of the accident, assumed to occur at the center of the site. In general, the maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas the minimum risks would occur under D stability with 4 m/s wind speed. An exception is worker impacts for the ammonia tank rupture, for which maximum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential irreversible adverse affects to an individual.

^f MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the site were used, which did not show receptors at the MEI locations.

^g These accidents would result in the largest plume sizes, although no people would be affected.

^h Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

ⁱ NA = not applicable.

- If the accidents identified in Tables 5.10 and 5.11 were to occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 770 (maximum corresponding to HF tank rupture), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 420 (maximum corresponding to ammonia tank rupture).
- The largest impacts would be caused by HF tank rupture; corroded cylinder spill, wet conditions – rain and water pool; ammonia tank rupture; and vehicle-induced fire involving three full 48G cylinders. Accidents involving stack emissions would have very small impacts compared with accidents involving releases at ground level due to the large dilution (and lower source terms due to filtration and deposition) involved with the stack emissions.
- The bounding accidents for the conversion options (conversion to U_3O_8 , UO_2 , and metal) would have nearly identical impacts.
- For the most severe accidents in each frequency category, the noninvolved worker MEI and the public MEI would have the potential for both adverse effects and irreversible adverse effects. The likely accidents for each conversion option (frequency of more than one chance in 100 per year) would result in no potential adverse or irreversible adverse effects for the general public. The generally reduced impacts to the public MEI compared with the noninvolved worker MEI are related to dispersion of the chemical release with downwind distance (except for UF_6 cylinder fire with plume rise).
- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009 through 2028). The results indicate that the maximum risk values would be less than 1 for all accidents except the following:

- *Potential Adverse Effects:*

Corroded cylinder spill, dry conditions (L, likely), workers
Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

- *Potential Irreversible Adverse Effects:*

Corroded cylinder spill, dry conditions (L, likely), workers
Ammonia stripper overpressure (L, likely), workers
Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for noninvolved workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated irreversible adverse effects was calculated. For the worker and general public accidents involving UF_6 releases shown in Table 5.10, exposure to HF and uranium compounds could be high enough to result in death for 1% or less of the persons experiencing irreversible adverse effects (PolICASTRO et al. 1997). Thus, for the corroded cylinder spill accidents having a range of 0 to 330 irreversible adverse effects for noninvolved workers, approximately 0 to 3 worker deaths would be expected; no deaths would be expected for members of the general public from such accidents. For the ammonia tank rupture accident caused by an earthquake, exposure to ammonia would result in death for about 2% of the persons experiencing irreversible adverse effects. This would correspond to about 4 to 8 deaths among noninvolved workers and 0 to 34 deaths for the general public. These are the maximum potential consequences of the accidents; the upper ends of the ranges result from assuming worst-case weather conditions, with the wind blowing in the direction where the highest number of people would be exposed.

5.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries to all conversion facility workers was calculated using industry-specific statistics from the U.S. Bureau of Labor Statistics, as reported by the National Safety Council (1995). Annual fatality and injury rates for construction and manufacturing, respectively, were used for the construction and operational phases of the conversion facility lifetime.

No on-the-job fatalities are predicted for any of the options analyzed, but a range of about 300 to 500 injuries is predicted during the conversion facility lifetimes. Overall, the largest impacts are predicted for conversion to UO_2 through gelation and for conversion to metal through batch reduction because these options require larger numbers of employees. All other conversion options would result in similar impacts; fewer impacts are predicted for the cylinder treatment facility (i.e., approximately 170 injuries).

Because the conversion technologies analyzed for conversion of U_3O_8 would employ almost the same number of workers, there are essentially no differences between them. There would be a probability of about 0.35 of an on-the-job fatality (sum of 0.18 for the construction phase and 0.17 for the operations phase) for the U_3O_8 conversion options (Table 5.12). The predicted injury incidence would be about 285 injuries over the lifetime of the facility.

TABLE 5.12 Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Conversion Options^a

Option	Impacts to Conversion Facility Workers ^b			
	Incidence of Fatalities		Incidence of Injuries	
	Construction	Operations	Construction	Operations
Conversion to U ₃ O ₈	0.18	0.16–0.17	66	215–219
Conversion to UO ₂	0.22–0.30	0.18–0.29	79–108	243–384
Conversion to metal	0.22–0.25	0.17–0.30	79–92	222–395
Cylinder treatment	0.08	0.11	30	140

^a Impacts are reported as ranges, which result from variations in the employment requirements for the different conversion technologies for each option.

^b Potential hazards were estimated for all conversion facility workers.

Source: Injury and fatality rates used in calculations taken from National Safety Council (1995).

The predicted probability of worker fatalities for conversion to UO₂ ranges from 0.4 to 0.59 (Table 5.12). The predicted injury incidence ranges from about 320 to 492 injuries over the lifetime of the UO₂ conversion facility. The upper ends of the ranges result from the larger number of workers required for operation of the gelation facility.

The predicted probability of worker fatalities for conversion to metal ranges from about 0.4 to 0.55 (Table 5.12). The predicted injury incidence ranges from about 300 to 490 injuries over the lifetime of the metal conversion facility. The upper ends of the ranges result from the larger number of workers required for operation of the batch reduction facility.

For the cylinder treatment facility option, the probability of an on-the-job fatality is about 0.19 (sum of 0.08 for the construction phase and 0.11 for the operations phase) (Table 5.12). The estimated injury incidence would be about 170 over the lifetime of the facility.

5.3.3 Air Quality

Additional details regarding the analysis of air quality impacts for the conversion option are presented in Tschanz (1997a).

5.3.3.1 Construction

The annual emissions of SO₂, NO₂, HC, CO, and PM₁₀ expected during conversion plant construction are listed in Table 5.13. The estimated 1-hour maximum pollutant concentrations at the facility boundary during construction are shown in Table 5.14. Additional estimates were made for the conversion technology that had the highest estimated 1-hour maximum pollutant concentrations (i.e., gelation); these estimated concentrations are given in Table 5.15. Although all of these pollutant concentrations would be much higher than those for plant operations, they would remain below ambient air quality standards. One possible exception is PM₁₀, for which concentrations were estimated to be about 80% of the 24-hour standard of 150 : g/m³. Some fugitive dust control measures would be necessary to mitigate this potentially high concentration. Construction of the conversion plant in a region of already high, even if compliant, ambient pollutant concentrations might require consideration of changes and/or controls for the emission of the other pollutants as well.

Estimated emissions from the cylinder treatment facility for all aspects of construction and operations are of the same order of magnitude (generally about 0.4 to 0.7 times as large) as those associated with the baseline cylinder transfer facility (see Section 4.3.3), and the cylinder treatment facility area would be about half as large as the baseline cylinder transfer facility area. Except for the 1-hour average results, the analytical results shown in Table 5.16 for the cylinder treatment facility are about 0.2 to 0.4 times as large as those shown in Table 4.7 of this document for the cylinder transfer facility. The 1-hour average impacts of construction of a cylinder treatment facility would be essentially the same as those for cylinder transfer facility construction.

TABLE 5.13 Emissions to the Atmosphere from Construction of a Depleted UF₆ Conversion Plant during the Peak Year

Option	Emissions to Atmosphere (tons/yr)				
	SO ₂	NO ₂	HC	CO	PM ₁₀
Conversion to U ₃ O ₈	2	28	8	190	40–50
Conversion to UO ₂	2–3	30–46	8–13	200–320	50–60
Conversion to metal	2–3	30–40	8–12	200–270	50–60

Source: LLNL (1997).

TABLE 5.14 Maximum 1-Hour Average Pollutant Concentrations at the Nearest Point on the Boundary from Construction of a Conversion Facility at the Paducah Site^a

Option	Pollutant (: g/m ³)				
	SO ₂	NO ₂	HC	CO	PM ₁₀
Conversion to U ₃ O ₈	26	360	100	2,400	520
Conversion to UO ₂	25–37	380–570	100–160	2,400–3,900	620–740
Conversion to metal	25–36	360–480	100–140	2,500–3,200	610–720

^a The ranges shown for some pollutants include results from the various technologies used for the conversion option.

TABLE 5.15 Maximum Air Quality Impacts from Conversion Facility Construction at the Paducah Site^a

Pollutant	Estimated Pollutant Emissions ^b							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concentration ^c (: g/m ³)	Fraction of Standard ^d	Concentration ^c (: g/m ³)	Fraction of Standard ^d	Concentration ^c (: g/m ³)	Fraction of Standard ^d	Concentration ^c (: g/m ³)	Fraction of Standard ^d
CO	3,810	0.1	1,800	0.18	—	—	—	—
NO _x	—	—	—	—	—	—	9.8	0.10
SO ₂	—	—	—	—	5.4	0.01	0.55	0.007
PM ₁₀	—	—	—	—	125	0.83	13	0.26

^a Estimated pollutant emissions are given for the conversion to UO₂ gelation option, which would have the highest emissions.

^b Values are listed only for pollutant/averaging time period combinations that have applicable air quality standards.

^c Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

^d Ratio of the concentration to the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A dash indicates those pollutant/averaging time period combinations for which no air quality standards exists.

TABLE 5.16 Air Quality Impacts from Construction of the Cylinder Treatment Facility

Pollutant	Estimated Pollutant Emissions							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concentration ^a (: g/m ³)	Fraction of Standard ^b	Concentration ^a (: g/m ³)	Fraction of Standard ^b	Concentration ^a (: g/m ³)	Fraction of Standard ^b	Concentration ^a (: g/m ³)	Fraction of Standard ^b
CO	3,500	0.088	450	0.045	180	–	7.2	–
NO _x	520	–	69	–	27	–	1.1	0.011
PM ₁₀	720	–	95	–	37	0.25	1.5	0.030

^a Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

^b Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded. Pollutant/averaging time period combinations for which no air quality standard exists are noted with a dash (–).

5.3.3.2 Operations

Hourly emission rates during operations were determined from annual emission rates given in the engineering analysis report (LLNL 1997); these rates are shown in Table 5.17. The methods used to analyze the impacts of pollutant emissions are described in Appendix C of the PEIS. All air pollutant concentrations during operations would be well below applicable ambient air quality standards for all conversion options. The maximum ground-level atmospheric concentrations at the site boundary from boiler and generator stack emissions are listed in Tables 5.18 through 5.20. The nearest any of the criteria pollutant concentrations would come to a corresponding air quality standard is the annual 8-hour average CO concentration, which would range up to about 4% of the standard for all conversion options.

Maximum air quality impacts from the process stacks are also listed in Tables 5.18 through 5.20. State HF standards in Kentucky have been used for comparative purposes. The estimated 24-hour maximum HF concentration at the site boundary for the conversion to U₃O₈ with anhydrous HF is about 2% of the state standard. The batch conversion to uranium metal is the only case for which NO_x would be emitted from the process stack, and the NO_x emission rate from the process stack in that case would be about seven times larger than from the boiler stack. Nevertheless, the estimated maximum annual NO_x concentration at the site boundary is less than 1% of the state standard.

TABLE 5.17 Emissions to the Atmosphere from Operation of a Depleted UF₆ Conversion Plant

Option/Source	Emissions to Atmosphere (lb/yr)						Uranium Compounds
	SO ₂	NO ₂	HC	CO	PM ₁₀	HF	
<i>Conversion to U₃O₈</i>							
Boiler stack	60–80	8,300–10,000	180–200	4,100–5,000	310–400	–	–
Process stack	–	–	–	–	–	300–900	3.3 U ₃ O ₈
Generator stack	60	400	400	2,300	80	–	–
<i>Conversion to UO₂</i>							
Boiler stack	23–820	3,800–110,000	170–2,300	800–55,000	290–4,100	–	–
Process stack	–	–	–	–	–	300–900	2.5–12 UO ₂
Generator stack	54–80	400–720	400–690	2,300–3,700	20–140	–	–
<i>Conversion to metal</i>							
Boiler stack	60–100	8,200–14,000	170–290	4,000–6,700	300–500	–	–
Process stack	–	117,000	–	–	–	300	1.2–9.6 U ₃ O ₈ ; 3.8 UF ₄
Generator stack	54–60	460–600	410–490	2,700–3,600	90–120	–	–

Source: LLNL (1997).

Each emergency generator would operate for 300 hours or less during 1 year. When it was operating, however, an emergency generator would produce higher concentrations of criteria pollutants at the facility boundaries than would the boiler. The estimated pollutant concentrations from the generator are listed in Tables 5.18 through 5.20. Compared with the air quality standards, the estimated concentrations are no more than 4% of allowed values.

The boiler stack parameters are identical for the cylinder treatment facility and the baseline cylinder transfer facility (Section 4.3.3). Given the similarities in the input data, the results of the air quality analyses for the two facilities should be expected to be comparable. Although not presented explicitly here, the same can be said of the impacts for operations. In summary, all of the criteria pollutant impacts of the cylinder treatment facility would not differ substantially from those of the cylinder transfer facility; all of the impacts not explicitly noted here are considered to be negligible. The only pollutant of concern emitted by the cylinder treatment facility process stack would be HF, and it, too, would be comparable for the two facilities. The cylinder treatment facility process stack would produce maximum annual average HF concentrations of 1.6×10^{-6} g/m³. This concentration is several orders of magnitude smaller than any applicable HF air quality standard.

TABLE 5.18 Air Quality Impacts from Operations for Conversion to U₃O₈ at the Paducah Site

Option/ Stack/ Pollutant	Estimated Pollutant Emissions ^a							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c
Conversion to U₃O₈ with Anhydrous HF								
Boiler stack								
CO	0.92	2×10^{-5}	0.51	5×10^{-5}	—	—	—	—
NO _x	—	—	—	—	—	—	0.058	0.0006
Generator stack								
CO	440	0.011	180	0.018	—	—	Not calculated	
NO _x	—	—	—	—	—	—	Not calculated	
Process stack								
HF	—	—	—	—	0.047	0.02	0.0046	1×10^{-5}
U ₃ O ₈	—	—	—	—	—	—	1.7×10^{-5}	NS ^d
Conversion to U₃O₈ with HF Neutralization								
Boiler stack								
CO	0.81	2×10^{-5}	0.43	4×10^{-5}	—	—	—	—
NO _x	—	—	—	—	—	—	0.050	0.0005
Generator stack								
CO	440	0.011	180	0.018	—	—	Not calculated	
NO _x	—	—	—	—	—	—	Not calculated	
Process stack								
HF	—	—	—	—	0.014	0.005	0.0015	4×10^{-6}
U ₃ O ₈	—	—	—	—	—	—	1.6×10^{-5}	NS

^a Values are listed only for pollutant/averaging time period combinations with air quality standards.

^b Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

^c Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded.

^d NS = No annual average air quality standard is available for U₃O₈.

TABLE 5.19 Air Quality Impacts from Operations for Conversion to UO₂ at the Paducah Site

Option/ Stack/ Pollutant	Estimated Pollutant Emissions ^a							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c
Conversion to UO₂ with Anhydrous HF								
Boiler stack								
CO	0.77	2×10^{-5}	0.43	4×10^{-5}	—	—	—	—
NO _x	—	—	—	—	—	—	0.050	0.0005
Generator stack								
CO	640	0.016	330	0.033	—	—	Not calculated	
NO _x	—	—	—	—	—	—	Not calculated	
Process stack								
HF	—	—	—	—	0.038	0.013	0.0039	1×10^{-5}
U ₃ O ₈	—	—	—	—	—	—	5.2×10^{-5}	NS ^d
Conversion to UO₂ with HF Neutralization								
Boiler stack								
CO	0.71	2×10^{-5}	0.39	4×10^{-5}	—	—	—	—
NO _x	—	—	—	—	—	—	0.046	0.0005
Generator stack								
CO	640	0.016	330	0.033	—	—	Not calculated	
NO _x	—	—	—	—	—	—	Not calculated	
Process stack								
HF	—	—	—	—	0.012	0.004	0.0013	3×10^{-6}
U ₃ O ₈	—	—	—	—	—	—	5.1×10^{-5}	NS ^d
Conversion to UO₂ with Gelation Process								
Boiler stack								
CO	1.8	5×10^{-5}	1.3	1×10^{-4}	—	—	—	—
NO _x	—	—	—	—	—	—	0.11	0.0011
Generator stack								
CO	NA ^e	NA	NA	NA	NA	NA	NA	NA
NO _x	NA	NA	NA	NA	NA	NA	NA	NA
Process stack								
HF	—	—	—	—	0.029	0.01	0.0028	7×10^{-6}
U ₃ O ₈	—	—	—	—	—	—	1.2×10^{-5}	NS ^d

^a Values are listed only for pollutant/averaging time period combinations with air quality standards.

^b Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

^c Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded.

^d NS = No annual average air quality standard is available for U₃O₈.

^e NA = Data not available.

TABLE 5.20 Air Quality Impacts from Operations for Conversion to Uranium Metal at the Paducah Site

Option/ Stack/ Pollutant	Estimated Pollutant Emissions ^a							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c	Range ^b (: g/m ³)	Fraction of Standard ^c
Batch Process								
Boiler stack								
CO	0.88	2×10^{-5}	0.50	5×10^{-5}	—	—	—	—
NO _x	—	—	—	—	—	—	0.061	0.0006
Generator stack								
CO	670	0.017	350	0.035	—	—	Not calculated	Not calculated
NO _x	—	—	—	—	—	—	Not calculated	Not calculated
Process stack								
HF	—	—	—	—	0.011	0.004	0.0011	3×10^{-6}
UF ₄	—	—	—	—	—	—	1.4×10^{-5}	NS ^d
U ₃ O ₈	—	—	—	—	—	—	3.6×10^{-5}	NS
NO ₂	—	—	—	—	—	—	0.44	0.007
Continuous Process								
Boiler stack								
CO	0.71	2×10^{-5}	0.39	4×10^{-5}	—	—	—	—
NO _x	—	—	—	—	—	—	0.046	0.0005
Generator stack								
CO	640	0.016	330	0.033	—	—	Not calculated	Not calculated
NO _x	—	—	—	—	—	—	Not calculated	Not calculated
Process stack								
HF	—	—	—	—	0.013	0.004	0.0013	3×10^{-6}
UF ₄	—	—	—	—	—	—	1.6×10^{-5}	NS
U ₃ O ₈	—	—	—	—	—	—	5.3×10^{-6}	NS

^a Values are listed only for pollutant/averaging time period combinations with air quality standards.

^b Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

^c Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded.

^d NS = No annual average air quality standard is available for this pollutant.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue that would be affected by emissions data for the entire area around a proposed conversion site. The pollutants most related to ozone formation that would result from the conversion of depleted UF_6 are HC and NO_x . In later Phase II studies, when specific technologies and sites would be selected, the potential effects on ozone of these pollutants at a proposed site could be put in perspective by comparing them with the total emissions of HC and NO_x in the surrounding area. Small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region.

5.3.4 Water and Soil

This section discusses impacts of the conversion options on surface water, groundwater, and soils. It uses the Paducah site as a representative conversion site. The major conversion option parameters are summarized in Table 5.21.

5.3.4.1 Surface Water

The methodology used to determine potential impacts to surface water for each conversion technology is described in Appendix C of the PEIS and Tomasko (1997b).

5.3.4.1.1 Conversion to U_3O_8

Construction. Construction of a U_3O_8 conversion facility at the Paducah site would produce increased runoff to nearby surface waters because of replacing soil and vegetation with either buildings or paved areas, approximately 13 acres (5.3 ha) (LLNL 1997). The amount of increased runoff would be negligible compared with the assumed existing area for runoff (0.4% of the site area). None of the construction activities would measurably affect floodplains.

Table 5.21 shows the quantity of water that would be used during construction of the U_3O_8 conversion facility (about 8 million gal/yr). This water would be withdrawn from the Ohio River. If the rate of water consumption were constant, the average rate of withdrawal would be about 15 gpm. This rate of withdrawal would be negligible compared to average flows in the Ohio River (less than 0.00001%). Construction impacts would, therefore, be negligible.

For construction, the net volume of water disposed of would be about 4 million gal/yr (7.6 gpm) (Table 5.21). The primary contaminants of concern would be construction chemicals, organics, and some suspended solids. The wastewater would be discharged to nearby surface waters under an NPDES permit, or to an appropriate wastewater sewer. By following good engineering practices (e.g., stockpiling materials away from surface water drainages, covering construction piles

TABLE 5.21 Summary of Conversion Option Parameters Affecting Water Quality and Soil^a

Option	Disturbed Land Area (acres)	Operations Area (acres)	Construction Water (million gal/yr)	Operations Water (million gal/yr)
Conversion to U ₃ O ₈	20	13	Raw = 8 Waste = 4	Raw = 34 – 47 Waste = 15 – 23 Sanitary = 1.2
Conversion to UO ₂	22 – 31	14 – 20	Raw = 4 – 12 Waste = 5 – 6	Raw = 41 – 285 Waste = 9.7 – 135 Sanitary = 0.7 – 2.3
Conversion to metal	23 – 26	15 – 16	Raw = 10 – 12 Waste = 5 – 6	Raw = 55 Waste = 25 – 26 Sanitary = 1.4 – 2.3

Option	Accident Scenario	Radioactive Release to Surface Water ^a (Ci/yr)	Radioactive Effluent Concentration ^b (pCi/L)	Dilution Factor ^c	Surface Water Concentration (pCi/L)
Conversion to U ₃ O ₈	HF pipeline break	0.001	12 – 17	47,000 – 4,200,000	4.1×10^{-6} to 2.6×10^{-4}
Conversion to UO ₂	HF pipeline break	0.002 – 0.003	6 – 21	42,000 – 500,000	1.2×10^{-5} to 5.0×10^{-4}
Conversion to metal	HF pipeline break	0.001 – 0.002	10 – 21	42,000 – 2,600,000	4.0×10^{-6} to 4.9×10^{-4}

^a Data from engineering analysis report (LLNL 1997).

^b Concentration derived from estimated annual radioactive release and annual wastewater discharge.

^c Dilution factor based on average flow conditions in receiving rivers.

with tarps to prevent erosion by precipitation, and cleaning up small chemical spills as soon as they occur), concentrations in the wastewater would be small (well below any drinking water criteria).

Once in the surface water, mixing and dilution of the pollutants would occur. This dilution would be greater than 15 million:1 for average flow conditions in the Ohio River. This amount of dilution would reduce any contamination present to concentrations well below regulatory standards. Because the concentration of contamination in the water would be very low, impacts to sediment in the streams would also be negligible.

Operations. For normal operations, no impacts would occur to surface runoff, and there would be no measurable impacts on floodplains (effluent discharges to surface waters less than 0.00004% of the average flow in the Ohio River). As indicated in Table 5.21, normal operation of the U_3O_8 conversion facility would require at most 47 million gal/yr (approximately 89 gpm) of raw water. If this water were obtained from the Ohio River, impacts would be negligible, less than 0.00007% of the average flow.

A maximum of 23 million gal/yr of wastewater would be generated during operations, including cooling tower blowdown, process water, and industrial waste water. Another 1.2 million gal/yr of sanitary wastewater would be produced (Table 5.21). For constant rates of discharge, about 44 gpm of wastewater and 2.3 gpm of sanitary water would be released to the environment at approved NPDES locations, producing negligible impacts.

The primary contaminants of concern for the wastewater would be uranium and chemicals used to inhibit rust, reduce friction, and enhance heat exchange (e.g., copolymers, phosphates, phosphonates, calcium, magnesium, nitrates, sodium, and potassium). As discussed in the engineering analysis report (LLNL 1997), approximately 0.001 Ci/yr of uranium with an activity of 4×10^{-7} Ci/g would be released in the discharge water. For a waste volume of 23 million gal/yr (Table 5.21), the uranium concentration in the effluent would be about 30 : g/L. After dilution, the concentration would be much less than the proposed EPA drinking water standard for uranium of 20 : g/L, used here for comparison. Concentrations of the other chemicals released would also be expected to be very low and within the guidelines of an NPDES permit.

Accident Scenarios. Most of the accidents analyzed would involve outdoor releases on impermeable concrete pads in the cylinder yards; such releases could be cleaned up with little loss of the contaminated material to the soil. The only postulated accident that would release contaminated water to the environment is an HF pipeline break produced by an earthquake (Table 5.21). Anhydrous HF would be pumped from the process building to the HF storage building through an underground pipeline that would carry liquid HF at a rate of 10 gpm (0.63 L/s) through 200 ft (61 m) of 1-in. (2.5-cm) pipe. For this accident scenario, 100% of the HF would drain into the ground at a point 3 ft (0.91 m) below grade during a 10-minute period. Approximately 500 lb (227 kg) of liquid HF (60 gal [227 L]) would be released. After 48 hours, the contaminated soil was assumed to be removed. Because of the rapid response to the accident, the HF would have little time to travel into the soil. For a silty sand soil, the travel distance would be about 2 ft (6.1 m) (Tomasko 1997b). Removal of the contaminated soil and soil water would prevent any contamination problems to the groundwater and would prevent any cross contamination with surface waters. Therefore, there would be no net impact from this accident. Because this accident scenario would not affect surface runoff or existing floodplains, impacts to these parameters would also be nonexistent.

5.3.4.1.2 Conversion to UO_2

The environmental parameters associated with the UO_2 conversion alternatives are similar to those for U_3O_8 conversion (Table 5.21), except for raw water use, which would be about five times larger for normal operations. If the water were withdrawn from the Ohio River, impacts would be negligible and would be less than 0.0004% of the average flows. Because of this option's similarities to the U_3O_8 conversion option, impacts to surface water produced by UO_2 conversion would be essentially the same as those for U_3O_8 conversion (i.e., negligible).

As was the case for the conversion to U_3O_8 option, discharge waters would contain from 0.002 to 0.003 Ci/yr. For the water volumes listed in Table 5.21, the equivalent concentrations would range from 6 to 76 pCi/L (30 to 400 : g/L). After dilution, concentrations would be much less than the EPA proposed drinking water standard for uranium, used here for comparison.

5.3.4.1.3 Conversion to Metal

The environmental parameters associated with conversion to metal are very similar to those for U_3O_8 conversion (Table 5.21); however, raw water usage for construction and normal operation would be about 50% higher. If the construction water was obtained from the Ohio River, the rate of withdrawal would be negligible compared to average flows (about 0.0002%). For normal operations, the increased rate of withdrawal would be less than 0.0001% of the average flow. This impact would be negligible.

As was the case for the conversion to U_3O_8 and UO_2 options, discharge waters would contain either 0.001 or 0.002 Ci/yr. For the water volumes listed in Table 5.21, the equivalent concentrations would range from 25 to 53 : g/L. After dilution, the concentrations would be much less than the EPA proposed drinking water standard for uranium, used here for comparison.

5.3.4.1.4 Cylinder Treatment

Construction and operation of the cylinder treatment facility would use less land and water and produce less wastewater than the construction and operation of conversion facilities, as shown in Table 5.22. Thus, potential impacts would be smaller. There are no postulated accidents that would directly release contaminants to surface water (LLNL 1997).

5.3.4.2 Groundwater

The methodology for assessing impacts to groundwater for each conversion technology is described in detail in Appendix C of the PEIS and Tomasko (1997b).

**TABLE 5.22 Summary of Environmental Parameters
for the Cylinder Treatment Facility**

Parameter	Unit	Construction	Operations	Accidents
Land area	acres	8.7	—	None
Disturbed land	acres	4.5	—	None
Water	million gal/yr	3.6	3.4	None
Wastewater ^a	million gal/yr	1.3	2.3	None

^a Includes sanitary wastewater, cooling tower blowdown, industrial water, and process water.

5.3.4.2.1 Conversion to U_3O_8

Potential impacts to groundwater could occur during construction, normal operations, and postulated accident scenarios. These impacts include the following: changes in effective recharge to underlying aquifers, changes in the depth to groundwater, changes in the direction of groundwater flow, and changes in groundwater quality.

Because all water used at Paducah is obtained from the Ohio River, there would be no impacts to groundwater recharge or depth as a result of groundwater extraction during construction and normal operations. In addition, there would be no impacts to groundwater quality from direct discharges to groundwater during construction or normal operations because none are planned. However, groundwater quality could be affected by accidental releases. Groundwater quality could also be affected by construction activities. For example, exposed chemicals could be mobilized by precipitation and infiltrate the surficial aquifers. By following good engineering and construction practices (e.g., covering chemicals to prevent interaction with rainfall, promptly cleaning up any chemical spills, and providing retention basins to catch and hold any contaminated runoff), groundwater concentrations would be less than the EPA guidelines.

As discussed in Section 5.3.4.1.1, only one accident scenario, the HF pipeline break, would potentially release contaminants to the groundwater (Table 5.21). Because of rapid mitigation and the small volume of HF in the release, this scenario would have a negligible impact on groundwater quality and would not affect recharge, depth to groundwater, or direction of flow.

5.3.4.2.2 Conversion to UO_2

The environmental parameters associated with the UO_2 conversion alternatives are very similar to those for U_3O_8 conversion (Table 5.21), except for raw water use during normal operations (about five times larger). Because this water would be obtained from the Ohio River, there would be no impacts to groundwater.

5.3.4.2.3 Conversion to Metal

The environmental parameters associated with the metal conversion alternatives are very similar to those for U_3O_8 conversion (Table 5.21), except for a 50% increase in raw water use during construction and normal operations. Because this water would be obtained from the Ohio River, there would be no impacts to groundwater.

During construction, groundwater concentrations would be kept below EPA guidelines (EPA 1996) by following good engineering practices. During normal operations, there would be no impacts to groundwater quality because direct discharges to groundwater are not planned.

5.3.4.2.4 Cylinder Treatment Facility

For the cylinder treatment facility, there would be no direct impacts to groundwater during normal operations because groundwater would not be used to supply the water required (Table 5.22) and there would be no discharges of wastewater to the ground. Impacts to groundwater during construction of the cylinder treatment facility include changes in effective recharge, changes in the depth to the water table, changes in the direction of groundwater flow, and changes in quality.

Construction of the cylinder treatment facility would decrease the permeability of about 4.5 acres (1.8 ha) of land because of paving and building. This loss of permeable land would reduce recharge, increase the depth to the water table, and change the direction of groundwater flow; however, because the area affected would be small (about 0.1% of the land area available), these impacts would be negligible and limited to small, local regions in the immediate vicinity of the paved lots and building footprints.

During construction, groundwater quality would also be impacted. For example, stockpiled chemicals could be mobilized by precipitation and infiltrate the surficial aquifers. By following good engineering and construction practices (e.g., covering chemicals to prevent interaction with rain, promptly cleaning up any chemical spills, and providing retention basins to catch and hold any contaminated runoff), groundwater concentrations would be less than the EPA guidelines.

5.3.4.3 Soil

The methodology for estimating potential impacts to soil is described in detail in Appendix C of the PEIS and Tomasko (1997).

5.3.4.3.1 *Conversion to U_3O_8*

Potential impacts to soil could occur during construction, normal operations, and postulated accident scenarios. These impacts include changes in topography, permeability, quality, and erosion potential.

Paving and construction would alter about 13 acres (5.3 ha) and potentially disturb up to 20 acres (8.1 ha) (LLNL 1997). Soil beneath the buildings and paved areas may be altered permanently. Although the alteration of these lands might be permanent, the net impact would be negligible (about 0.3% of the land area available). A larger percentage is associated with the potential land area disturbed (about 0.5% of the land area available). These impacts could include increased permeability, modification of the local topography, changes in the soil chemistry, and increases in the potential for soil erosion. These impacts would, however, be insignificant on a sitewide scale. In addition, impacts to these areas would be mitigated with time (e.g., disturbed soil would be regraded to natural contours and seeded with natural vegetation, thereby returning the soils to their original condition).

By following good engineering practices (e.g., disturbing as little soil as possible, contouring and reseeding disturbed lands, scheduling construction activities to minimize land disturbance, controlling runoff, using tarps to prevent chemical/precipitation interactions, and cleaning up any spills as soon as they occurred), negligible impacts to soils would occur.

Because normal operations would not affect soil, there would be no soil impacts. The only accident identified that could potentially impact the soil is an HF pipeline rupture (Table 5.21), discussed in Section 5.3.4.1.1. Because of rapid mitigation (any contaminated soil would be cleaned up within 48 hours of the rupture) and the small release volume (60 gal of HF), impacts to the soil would be negligible.

5.3.4.3.2 *Conversion to UO_2*

The environmental parameters associated with the UO_2 conversion alternatives are very similar to those for U_3O_8 conversion (Table 5.21). Because of these similarities, impacts to soil for UO_2 conversion would be negligible.

5.3.4.3.3 Conversion to Metal

The environmental parameters associated with the metal conversion alternatives are very similar to those for U_3O_8 conversion (Table 5.21). Because of these similarities, impacts to soils would be essentially the same as those previously presented, i.e., none to negligible.

5.3.4.3.4 Cylinder Treatment Facility

For the cylinder treatment facility, the only impacts would occur during construction. There would be no discharges to the ground under normal operations, and there are no accidents identified in LLNL (1997) that would lead to direct contamination of the soil. Impacts from construction would include changes in topography, permeability, quality, and erosion potential. By following good engineering and construction practices (e.g., covering chemicals with tarps, cleaning up chemical spills as soon as they occur, and providing retention basins to catch and hold any contaminated surface runoff), impacts to soil quality would be negligible.

5.3.5 Socioeconomics

The impact of each conversion option on socioeconomic activity was estimated for an ROI surrounding the Paducah site. The assessment methodology is discussed in Appendix C of the PEIS and Allison and Folga (1997).

Each of the conversion options is likely to have a small impact on socioeconomic conditions in the ROI surrounding the site described in Chapter 2, Section 2.8. This is largely because a major proportion of the expenditures associated with procurement for the construction and operation of each technology option flows outside the ROI to other locations in the United States, reducing the concentration of local economic effects of each conversion option.

Slight changes in employment and income would occur in the ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required to construct and operate each conversion option, and other local investment associated with construction and operation. In addition to creating new (direct) jobs at the site, each conversion option would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures. Jobs and income created directly by each conversion option, together with indirect activity in the ROI, would contribute slightly to reduction in unemployment in the ROI surrounding the site. Minimal impacts are expected on local population growth, and consequently on local housing markets and local fiscal conditions.

The effects of constructing and operating each conversion technology on regional economic activity (measured in terms of employment and personal income) and on population, housing, and local public revenues and expenditures are described in Sections 5.3.5.1 through 5.3.5.4. Impacts are presented as ranges to include impacts that would occur with each conversion option and for the cylinder treatment facility at the site. Impacts are presented for the peak year of construction (assumed to be 2007); operations values are averages for the period 2009 through 2028. The potential impacts for each conversion option and for the cylinder treatment facility are presented in Table 5.23.

5.3.5.1 Conversion to U_3O_8

During the peak year of construction of a U_3O_8 conversion facility, between 240 and 250 direct jobs would be created at the site and 220 to 230 additional jobs would be created indirectly in the site ROI (Table 5.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 460 to 480 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income ranging from \$14 million to \$15 million during the peak year. During the first year of operations of the U_3O_8 conversion facility, 490 to 510 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with total income ranging from \$14 million to \$15 million. Construction and operation of the conversion facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of less than 0.1 percentage point from 1999 through 2028.

Construction of the U_3O_8 conversion facility would be expected to generate direct in-migration of 330 to 340 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROI, bringing the total number of in-migrants to 470 in the peak year (Table 5.23). Operation of the U_3O_8 conversion facility would be expected to generate direct and indirect job in-migration of 340 in the first year of operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.1 percentage point from 1998 through 2028.

A U_3O_8 conversion facility would generate a demand for 170 additional rental housing units during the peak year of construction (Table 5.23), representing an impact of 11% on the projected number of vacant rental housing units in the site ROI. A demand for 120 to 130 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 2.6 to 2.7% on the number of vacant owner-occupied housing units in the ROI.

TABLE 5.23 Potential Socioeconomic Impacts of the Conversion Options for the Paducah Site

	Conversion to U ₃ O ₈		Conversion to UO ₂	
	Construction ^a	Operations ^b	Construction ^a	Operations ^b
Economic activity in the ROI				
Direct jobs	240 – 250	200 – 210	330 – 630	230 – 360
Indirect jobs	220 – 230	290 – 300	300 – 530	370 – 670
Total jobs	460 – 480	490 – 510	630 – 1,200	600 – 1,000
Income (\$ million)				
Direct income	11	10	15 – 28	11 – 18
Total income	14 – 15	14 – 15	20 – 37	17 – 28
Population in-migration into the ROI	470	340	640 – 1,200	300 – 1,100
Housing demand				
Number of units in the ROI	170	120 – 130	240 – 440	110 – 390
Public finances				
Change in ROI fiscal balance (%)	0.3	0.2	0.2 – 0.7	<0.2 – 0.6
<hr/>				
	Conversion to Uranium Metal		Cylinder Treatment Facility	
	Construction ^a	Operations ^b	Construction ^a	Operations ^b
Economic activity in the ROI				
Direct jobs	380 – 440	210 – 370	100	130
Indirect jobs	290 – 330	370 – 520	80	160
Total jobs	670 – 770	580 – 890	180	290
Income (\$ million)				
Direct income	12 – 16	10 – 18	5	10
Total income	17 – 22	16 – 26	6	13
Population in-migration into the ROI	730 – 790	390 – 630	180	300
Housing demand				
Number of units in the ROI	270 – 290	140 – 230	70	110
Public finances				
Change in ROI fiscal balance (%)	0.5	<0.3 – 0.4	0.1	0.2

^a Impacts are for the peak year of construction, 2007. Socioeconomic impacts were assessed for 1999 through 2008.

^b Impacts are the annual averages for operations for the period 2009 through 2028.

During the peak year of construction, 470 people would be expected to in-migrate into the ROI at the site, leading to an increase of 0.3% over forecasted baseline revenues and expenditures in the site ROI (Table 5.23). In the first year of operations, 340 in-migrants would be expected, leading to an increase of 0.2% in local revenues and expenditures.

5.3.5.2 Conversion to UO₂

During the peak year of construction of a UO₂ conversion facility, 330 to 630 direct jobs would be created at the site and 300 to 530 additional jobs indirectly in the site ROI (Table 5.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 630 to 1,200 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income ranging from \$20 million to \$37 million during the peak year. During the first year of operations of the UO₂ conversion facility, 600 to 1,000 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with total income ranging from \$17 million to \$28 million. Construction and operation of the conversion facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of less than 0.1 percentage point from 1999 through 2028.

Construction of the UO₂ conversion facility would be expected to generate direct in-migration of 460 to 860 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROI, bringing the total number of in-migrants to between 640 and 1,200 in the peak year (Table 5.23). Operation of the UO₂ conversion facility would be expected to generate direct and indirect job in-migration of 300 to 1,100 in the first year of operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.1 percentage point from 1999 through 2028.

The UO₂ conversion facility would generate a demand for 240 to 440 additional rental housing units during the peak year of construction, representing an impact of 15 to 28% on the projected number of vacant rental housing units in the site ROI (Table 5.23). A demand for 110 to 390 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 3.2 to 8.2% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 640 to 1,200 people would be expected to in-migrate into the ROI at the site, leading to increases of 0.2 to 0.7% over forecasted baseline revenues and expenditures in the site ROI (Table 5.23). In the first year of operations, 300 to 1,100 in-migrants would be expected, leading to increases of less than 0.2 to 0.6% in local revenues and expenditures.

5.3.5.3 Conversion to Metal

During the peak year of construction of a metal conversion facility, 380 to 440 direct jobs would be created at the site and 290 to 330 additional jobs indirectly in the site ROI (Table 5.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 670 to 770 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income ranging from \$17 million to \$22 million during the peak year. During the first year of operations of the metal conversion facility, 580 to 890 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with total income ranging from \$16 million to \$26 million. Construction and operation of the conversion facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of less than 0.1 percentage point from 1999 through 2028.

Construction of the metal conversion facility would be expected to generate direct in-migration of 520 to 600 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROI, bringing the total number of in-migrants to between 730 and 790 in the peak year (Table 5.23). Operation of the metal conversion facility would be expected to generate direct and indirect job in-migration of 390 to 630 in the first year of operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.1 percentage point from 1999 through 2028.

The metal conversion facility would generate a demand for 270 to 290 additional rental housing units during the peak year of construction, representing an impact of 17 to 19% on the projected number of vacant rental housing units in the site ROI (Table 5.23). A demand for 140 to 230 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 3.0 to 4.9% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 730 to 790 people would be expected to in-migrate into the ROI surrounding the site, leading to increases of 0.5% over forecasted baseline revenues and expenditures in the site ROI (Table 5.23). In the first year of operations, 390 to 630 in-migrants would be expected, leading to increases of less than 0.3 to 0.4% in local revenues and expenditures.

5.3.5.4 Cylinder Treatment Facility

During the peak year of construction of a cylinder treatment facility, approximately 100 direct jobs would be created at the site and 80 additional jobs indirectly in the site ROI (Table 5.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 180 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income of \$6 million created during

the peak year. During the first year of operations of the cylinder treatment facility, 290 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with total income of \$13 million created in the first year. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of less than 0.1 percentage point from 1999 through 2028.

Construction of the cylinder treatment facility would be expected to generate direct in-migration of 140 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROI, bringing the total number of in-migrants to 180 in the peak year (Table 5.23). Operation of the cylinder treatment facility would be expected to generate direct and indirect job in-migration of 300 in the first year of operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.1 percentage point from 1999 through 2028.

The cylinder treatment facility would generate a demand for 70 additional rental housing units during the peak year of construction, representing an impact of 4.4% on the projected number of vacant rental housing units in the site ROI (Table 5.23). A demand for 110 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 2.3% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 180 people would be expected to in-migrate into the ROI surrounding the site, leading to an increase of 0.1% over forecasted baseline revenues and expenditures in the site ROI (Table 5.23). In the first year of operations, 300 in-migrants would be expected, leading to an increase of 0.2% in local revenues and expenditures.

5.3.6 Ecology

Moderate impacts to ecological resources could result from construction of a conversion facility. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a conversion facility would be negligible. Potential impacts to vegetation, wildlife, wetlands, and threatened and endangered species were assessed. The methodology used in the ecological impact analysis is discussed in Appendix C of the PEIS.

5.3.6.1 Conversion to U_3O_8

Site preparation for the construction of a facility to convert UF_6 to U_3O_8 would require the disturbance of approximately 20 acres (8 ha), including the permanent replacement of approximately 13 acres (5.3 ha) with structures and paved areas. Existing vegetation would be destroyed during land clearing activities. Determination of the vegetation communities that would be eliminated by site preparation would depend on the future location of the facility. Communities occurring on undeveloped land at the Paducah site are relatively common and well represented in the vicinity of

the site. Impacts to high-quality native plant communities may occur if facility construction requires disturbance to vegetation communities outside of the currently fenced area (see Section 5.3.9 for a discussion of land use). Construction of the conversion facility would not be expected to threaten the local population of any species. The loss of up to 20 acres (8 ha) of undeveloped land would constitute a moderate adverse impact. Erosion of exposed soil at construction sites could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table 5.24.

TABLE 5.24 Impacts to Ecological Resources from Construction of a Conversion Facility and Cylinder Treatment Facility

Option/Resource	Type of Impact	Degree of Impact
<i>Conversion to U_3O_8</i>		
Vegetation	Loss of 20 acres	Moderate adverse
Wildlife	Loss of 13 to 20 acres	Minor to moderate adverse
Wetlands	Loss, degradation	Potential adverse
Aquatic species	Water quality, habitat reduction	Negligible
Protected species	Destruction, habitat loss	Potential adverse
<i>Conversion to UO_2</i>		
Vegetation	Loss of 22 to 31 acres	Moderate adverse
Wildlife	Loss of 14 to 31 acres	Moderate adverse
Wetlands	Loss, degradation	Potential adverse
Aquatic species	Water quality, habitat reduction	Negligible
Protected species	Destruction, habitat loss	Potential adverse
<i>Conversion to metal</i>		
Vegetation	Loss of 23 to 26 acres	Moderate adverse
Wildlife	Loss of 15 to 26 acres	Moderate adverse
Wetlands	Loss, degradation	Potential adverse
Aquatic species	Water quality, habitat reduction	Negligible
Protected species	Destruction, habitat loss	Potential adverse
<i>Cylinder treatment facility</i>		
Vegetation	Loss of 9 acres	Moderate adverse
Wildlife	Loss of 5 to 9 acres	Moderate adverse
Wetlands	Loss, degradation	Potential adverse
Aquatic species	Water quality, habitat reduction	Negligible
Protected species	Destruction, habitat loss	Potential adverse

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities, and thus competition for food and nesting sites, would increase in these areas, potentially reducing the survivability or reproductive capacity of displaced individuals. Many wildlife species would be expected to quickly recolonize replanted areas near the conversion facility following completion of construction. The permanent loss of up to 13 acres (5.3 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the site. Therefore, construction of a conversion facility for U_3O_8 production would be considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section 5.3.4). Thus, construction-derived impacts to aquatic biota would also be expected to be negligible. Wetlands could potentially be impacted by filling or draining during construction. Impacts to wetlands due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the conversion facility were located immediately adjacent to wetland areas. However, impacts to wetlands would be minimized by maintaining a buffer area around wetlands during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Water Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

Critical habitat has not been designated for any state or federally listed threatened or endangered species at the Paducah site. Prior to construction of a conversion facility, a site-specific survey for federal- and state-listed threatened, endangered, or candidate species or species of special concern would be conducted. Impacts to these species could thus be avoided or, where impacts were unavoidable, appropriate mitigation could be developed.

During operations, ecological resources in the vicinity of the conversion facility would be exposed to atmospheric emissions from the boiler stack and process stack; however, emission levels would be expected to be extremely low (Section 5.3.3.2). The highest average air concentration of U_3O_8 would be less than 1.7×10^{-8} mg/m³. This would result in a radiation exposure to the general public (nearly 100% due to inhalation) of less than 0.009 mrem/yr, well below the DOE guideline of 100 mrem/yr (0.00027 rad/d). Wildlife species are less sensitive to radiation than humans (proposed DOE guidelines would require an absorbed dose limit to terrestrial animals of 0.1 rad/d). Therefore, impacts to wildlife due to radiation effects would be expected to be negligible. Toxic effects of chronic inhalation of U_3O_8 are minor at a concentration of 17 mg/m³ for tested animal species. This is many orders of magnitude greater than expected emissions. Therefore, toxic effects to wildlife due to U_3O_8 inhalation would also be expected to be negligible.

The maximum average air concentration of HF due to operation of a conversion facility would be 4.6×10^{-6} mg/m³. Chronic exposure to HF gas produces only mild effects in tested animal

species at concentrations as high as 7 mg/m^3 , considerably higher than expected emissions. Therefore, toxic effects to wildlife from HF emissions would be expected to be negligible.

A portion of the U_3O_8 released from the process stack of a conversion facility would become deposited on the soils surrounding the site. Uptake of uranium-containing compounds can cause adverse effects to vegetation. Deposition of U_3O_8 on soils, resulting from atmospheric emissions, would result in soil uranium concentrations considerably below the lowest concentration known to produce toxic effects in plants. Therefore, toxic effects on vegetation due to U_3O_8 uptake would be expected to be negligible.

Effluent discharges to surface waters would result in a uranium concentration of about 12 pCi/L (0.03 mg/L) as uranyl nitrate. Resulting dose rates to maximally exposed organisms would be considerably lower than the dose limit of 1 rad/d for aquatic organisms, which is required by DOE Order 5400.5. Uranyl nitrate concentrations in the effluent also would be considerably lower than 0.15 mg/L , the lowest concentration known to cause toxic effects in aquatic biota. Mixing of the effluent with surface water downstream of the outfall would result in a dilution factor of 2,500,000. Therefore, impacts to aquatic biota would be considered to be negligible.

For the U_3O_8 conversion process, water withdrawal from surface waters or groundwater, as well as wastewater discharge, could potentially alter water levels which could in turn affect aquatic ecosystems including wetlands (including wetlands located along the periphery of these surface water bodies). However, water level changes due to process water withdrawal and wastewater discharge would be negligible (Section 5.3.4.1). Therefore, impacts to wetlands would be expected to be negligible.

A potential release of contaminants due to the occurrence of an earthquake was analyzed. The subsequent rupture of an HF pipeline would potentially release anhydrous HF into the surrounding soil, surface water, or groundwater. Due to the brief duration of the release, the small volume involved, and rapid mitigation, the expected impacts to surface water, groundwater, and soil would be negligible. Therefore, impacts to ecological resources from such an accident would also be expected to be negligible. Facility accidents could result in adverse impacts to ecological resources. The affected species and the degree of impact would depend on a number of factors such as location of the accident, season, and meteorological conditions.

5.3.6.2 Conversion to UO_2

The construction of a facility to convert depleted UF_6 to UO_2 would generally result in the types of impacts associated with conversion to U_3O_8 . Site preparation for the construction of a facility to convert depleted UF_6 to UO_2 would require the disturbance of approximately 22 to 31 acres (8.9 to 12.5 ha), including the permanent replacement of approximately 14 to 19 acres

(5.5 to 7.8 ha) with structures and paved areas. The loss of 22 to 31 acres (8.9 to 12.5 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. The permanent loss of up to 19 acres (7.8 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the site. However, habitat use in the vicinity of the facility might be greatly reduced for many species due to the construction of a perimeter fence. Consequently, the construction of a conversion facility for UO_2 production is considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction would be expected to be negligible. Thus, construction-derived impacts to aquatic biota would also be expected to be negligible. Impacts to wetlands and protected species due to facility construction would be similar to impacts associated with conversion to U_3O_8 .

During operations, exposures to contaminants from conversion to UO_2 would generally be slightly larger than for conversion to U_3O_8 , but all exposures would be well below levels that might produce adverse effects. All impacts would therefore be negligible. Impacts to ecological resources from accident scenarios would be as discussed for conversion to U_3O_8 .

5.3.6.3 Conversion to Metal

Construction of a facility to convert depleted UF_6 to uranium metal would generally result in the types of impacts associated with conversion to U_3O_8 . Site preparation would require the disturbance of approximately 23 to 26 acres (9.4 to 11 ha), including the permanent replacement of about 15 to 16 acres (6.2 to 6.5 ha) with structures and paved areas. The loss of 23 to 26 acres (9.4 to 11 ha) of undeveloped land would constitute a moderate adverse impact to vegetation and wildlife. Impacts due to facility construction are shown in Table 5.24.

During operation of the metal conversion facility, exposure to contaminants would be considerably below levels known to cause toxic effects in biota. The resulting impacts would therefore be negligible. Impacts to ecological resources from accidents would be as discussed for conversion to U_3O_8 .

Construction of a cylinder treatment facility would generally result in the types of impacts associated with construction of a conversion facility; however, the area affected would be smaller (Table 5.24). Site preparation for constructing a cylinder treatment facility would require the disturbance of approximately 9 acres (4 ha). About 5 acres (2 ha) would be permanently replaced with structures, paved areas, and landscaping. The loss of 9 acres (4 ha) of undeveloped land would constitute a moderate adverse impact to vegetation and wildlife. Exposure to contaminants resulting from operation of a cylinder treatment facility would be considerably below levels known to result in toxic effects to biota. The resulting impacts would therefore be negligible.

5.3.7 Waste Management

Impacts on waste management from wastes generated during construction and normal operations at the depleted UF_6 conversion facilities would be caused by the potential overload of waste treatment and/or disposal capabilities either at the site or on a regional/national scale. The types of wastes that are expected to be generated by the depleted UF_6 conversion include LLW, LLMW, hazardous waste, nonhazardous solid waste, and nonhazardous wastewater. Currently, there are numerous DOE and commercial facilities that treat and/or dispose of LLW, hazardous waste, nonhazardous solid waste, and wastewaters. The treatment/disposal of LLMW is limited by regulatory and technological restrictions.

5.3.7.1 Conversion to U_3O_8

Construction of a facility at the Paducah site to convert UF_6 into U_3O_8 would generate both hazardous and nonhazardous wastes. Approximately 115 m^3 of hazardous waste, 700 m^3 of nonhazardous solid waste, and $15,000 \text{ m}^3$ of wastewater would be generated during construction (see Table 5.25). This compares with an existing contribution for hazardous waste of approximately $80 \text{ m}^3/\text{yr}$, a solid waste load at the Paducah site of $2,100 \text{ m}^3/\text{yr}$, and a wastewater load of $560,000 \text{ m}^3$ annually for the Paducah site (see Section 2.9). No radioactive waste would be generated during the construction phase of the facility. Overall, low to moderate waste management impacts would result from construction-generated wastes.

Operations at the facility to convert UF_6 into U_3O_8 would generate radioactive, hazardous, and nonhazardous wastes (Table 5.25). The conversion facility would generate 140 to $600 \text{ m}^3/\text{yr}$ of LLW, which, at the upper end, represents approximately 27% of the Paducah site annual LLW load. The U_3O_8 conversion facility waste input would represent less than 1% of DOE LLW generation. The U_3O_8 conversion facility would generate approximately $1.1 \text{ m}^3/\text{yr}$ of LLMW, which is about 1% of the LLMW generation at the Paducah site. The U_3O_8 conversion facility would generate approximately $7 \text{ m}^3/\text{yr}$ of hazardous waste, which would result in an increase of about 9% of the hazardous waste loads at the Paducah site; and about 60,000 to $90,000 \text{ m}^3/\text{yr}$ of wastewater, representing between 11 and 16% of the current load for wastewater at the Paducah site.

The CaF_2 potentially produced in the U_3O_8 conversion process was assumed to have a uranium content of less than 1 ppm (LLNL 1997). It is currently unknown whether this CaF_2 could be sold (e.g., as feedstock for commercial production of anhydrous HF) or whether the low uranium content would require disposal as either a nonhazardous solid waste or as LLW. The nonhazardous solid waste generation estimates for conversion to U_3O_8 and UO_2 , as shown in Table 5.25, are based on the assumption that CaF_2 would be disposed of as nonhazardous solid waste, generating approximately 240 to $11,000 \text{ m}^3/\text{yr}$ of nonhazardous solid waste (from 11 to 500% of the current

TABLE 5.25 Wastes Generated from Construction and Operations Activities for Depleted UF₆ Conversion^a

Activity/ Waste Category	Volume Ranges for the Options		
	Conversion to U ₃ O ₈	Conversion to UO ₂	Conversion to Metal
Construction^a (m³)			
Low-level waste	—	—	—
Low-level mixed waste	—	—	—
Hazardous waste	115	140 – 200	140 – 180
Nonhazardous waste			
Solids	700	1,300	860 – 1,130
Wastewater	3,800	7,600	5,700 – 7,580
Sanitary wastewater	11,400	17,000	13,200 – 15,200
Operations (m³/yr)			
Low-level waste			
Combustible waste	76.5	88.0 – 136	76.5 – 420
Noncombustible	62 – 68.2	82.0 – 140	112 – 470
Grouted	0 – 466	0 – 466	0 – 997
Total	140 – 600	170 – 740	190 – 1,890
Low-level mixed waste	1.1	1.1 – 8.8	1.1
Hazardous waste	7.32	7.32 – 17	7.32 – 9.5
Nonhazardous waste			
Solids	380 – 11,000 ^b	520 – 30,600 ^b	6,580 – 6,840 ^c
Wastewater	58,000 – 87,100	74,900 – 510,000	94,000 – 96,500
Sanitary wastewater	4,540 – 4,920	5,680 – 8,700	5,300 – 8,700

^a Total waste generated during construction period of 4 years.

^b Includes 240 to 10,630 m³ of CaF₂.

^c Includes 67 m³ of CaF₂ and 5,850 to 6,110 m³ of MgF₂.

nonhazardous solid waste loads at the Paducah site, depending on the conversion technology chosen). If CaF_2 were considered to be LLW, it would represent an additional 11 to 480% of the current LLW load. The upper end of the range of nonhazardous and LLW volume increases (which correspond to the HF neutralization process) would constitute a potentially large impact to either nonhazardous or LLW management activities at the Paducah site. Disposal as LLW might require the CaF_2 to be grouted, generating up to 21,300 m^3/yr of grouted waste. The maximum volume of LLW generated would still represent less than 10.4% of the projected DOE complexwide LLW disposal volume, constituting a moderate impact with respect to complexwide LLW management. It is also unknown whether CaF_2 LLW would be considered DOE waste if the conversion were conducted by a private commercial enterprise. If CaF_2 could be sold, the nonhazardous solid waste or LLW management impacts would be reduced to a low level for U_3O_8 conversion technologies.

The impacts from normal operation of the U_3O_8 conversion facility would range from negligible to large, depending upon the choice of technology and the ultimate generation volumes and disposition of CaF_2 for the facility. Overall, the waste input resulting from normal operations at the U_3O_8 conversion facility would be expected to have a moderate impact on waste management. If CaF_2 were disposed of as nonhazardous solid waste, the increased input could be managed by expanding the capacity of the nonhazardous solid waste disposal facilities at the site.

5.3.7.2 Conversion to UO_2

Construction of a facility to convert UF_6 into UO_2 would generate approximately the same quantity of hazardous wastes as conversion to U_3O_8 . Construction would generate approximately 1,300 m^3 of solid nonhazardous wastes and up to 24,000 m^3 of wastewater (see Table 5.25). These waste loads are well below the Paducah site waste inputs for comparable nonhazardous wastes and comparable to the hazardous waste inputs. No radioactive waste would be generated during the construction phase of the facility. Overall, only minimal waste management impacts would result from construction-generated wastes.

Operations at the facility to convert UF_6 into UO_2 would generate radioactive, hazardous, and nonhazardous wastes (Table 5.25). The conversion facility would generate about 8 to 34% of the Paducah site LLW loads. The UO_2 conversion facility would generate up to 465 m^3/yr of a solid, grouted LLW that would require off-site disposal. The conversion facility LLW input would represent less than 1% of the projected annual DOE LLW treatment volume. The UO_2 conversion facility would generate from 1 to 9% of the LLMW generation for the Paducah site. The UO_2 conversion facility would generate 7 to 17 m^3/yr of hazardous waste, which represents a 10 to 22% increase to the hazardous waste load from routine operations. The UO_2 conversion facility would add 520 to 30,600 m^3/yr of nonhazardous solid waste, representing 25–1,500% of the nonhazardous solid waste load at the Paducah site. The expected 80,000 to 500,000 m^3/yr of wastewater (see Table 5.25) represents a 14–90% addition to the current site wastewater load.

As in the U_3O_8 conversion option, it is currently unknown whether CaF_2 generated in the conversion to UO_2 option could be sold or whether the low uranium content (less than 1 ppm) would require disposal as either a nonhazardous solid waste or as LLW. The nonhazardous solid waste generation estimates for conversion to UO_2 shown in Table 5.25 are based on the assumption that CaF_2 would be disposed of as nonhazardous solid waste, generating about 240 to 11,000 m^3/yr of nonhazardous solid waste (up to 500% of the current nonhazardous solid waste load at the Paducah site, depending on the conversion technology chosen). If CaF_2 were considered to be LLW, it would represent up to 500% of the current LLW load at the site. The upper end of the range of nonhazardous and LLW volume increases (which correspond to the HF neutralization process) would constitute a potentially large impact to either nonhazardous or LLW management activities at the site. Disposal as a LLW might require the CaF_2 to be grouted, generating up to 21,300 m^3/yr of grouted waste. However, the maximum volume of LLW generated would still represent less than 10.4% of the projected DOE complexwide LLW disposal volume, constituting a moderate impact with respect to complexwide LLW management, if the CaF_2 were considered DOE waste. If CaF_2 could be sold, the nonhazardous solid waste or LLW management impacts would be reduced to a low level for UO_2 conversion technologies.

The large range in the expected volume of nonhazardous solid waste and wastewater is also a result of differences in UO_2 conversion technologies. The gelation technology would result in the highest nonhazardous waste generation volumes. The range of 520 to 30,600 m^3/yr for nonhazardous solid wastes represents an approximate range of 2–1,500% (15 times) the annual nonhazardous solid waste production at the Paducah site. The estimated range for wastewater generation represents a range of about 14–90% of the annual wastewater generation at the Paducah site.

The impacts from normal operation of the UO_2 conversion facility would range from negligible to large, depending upon the choice of technology for this facility. Overall, the waste input resulting from normal operations at the UO_2 conversion facility would be expected to have a moderate impact on waste management. The increased solid waste input could be managed by expanding the capacity of the solid nonhazardous waste disposal facilities at the sites. The increased wastewater input would be handled by existing site wastewater capabilities of the Paducah site.

5.3.7.3 Conversion to Metal

Construction of the facility to convert UF_6 into uranium metal at the Paducah site would generate approximately the same quantity of hazardous and nonhazardous wastes as conversion to U_3O_8 or UO_2 (Table 5.25). No radioactive waste would be generated during the construction phase of the facility. Overall, only minimal waste management impacts would result from construction-generated wastes.

Operations at the facility to convert UF_6 into uranium metal would generate radioactive, hazardous, and nonhazardous wastes (Table 5.25). The metal conversion facility would generate about 9 to 85% of the Paducah site LLW load. A metal conversion facility LLW input would

represent less than 3% of the projected annual DOE LLW treatment volume. The metal conversion facility would generate about 1% of the LLMW generation at the Paducah site and less than 12% of the hazardous waste load from routine operations at the site. The metal conversion facility would add about 325% of the existing Paducah site solid waste load and 19% of the load for wastewater. The increased solid waste input could be managed by expanding the disposal capacity of the solid nonhazardous waste disposal facilities at the Paducah site.

It is possible that the MgF_2 waste generated in the conversion to metal option would be sufficiently contaminated with uranium to require disposal as LLW rather than as solid nonhazardous waste. The uranium level in the MgF_2 is estimated to be about 90 ppm (LLNL 1997). Such disposal might require the MgF_2 waste to be grouted, generating about 6,150 to 12,300 m^3/yr of grouted waste for LLW disposal. This volume range represents about 280 to 560% of the current LLW generation for the Paducah site. However, it would represent less than 6% of the projected DOE complexwide LLW disposal volume, constituting a low impact with respect to complexwide LLW management, if the MgF_2 were considered a DOE waste.

Neutralization of HF to CaF_2 was not explicitly analyzed in the engineering analysis report for the conversion to metal options (LLNL 1997). However, the process could be implemented and would produce approximately one-third as much CaF_2 as would be produced under the conversion to oxide with neutralization options (i.e., approximately 3,500 m^3/yr of CaF_2). If this CaF_2 waste were disposed of as LLW, it would constitute less than 3% of the DOE complexwide LLW disposal volume, representing a low impact with respect to complexwide LLW management.

Overall, the waste input resulting from normal operations at the uranium metal conversion facility would have a moderate impact on waste management.

5.3.7.4 Cylinder Treatment Facility

All of the conversion options would require the removal of depleted UF_6 from the storage cylinders, resulting in a large number of empty cylinders. These empty UF_6 cylinders from the conversion facility would be decontaminated at the cylinder treatment facility and then are assumed to be added to the DOE scrap metal inventory. It was assumed for this assessment that the cylinder treatment facility would be washing the empty cylinders with water to remove the “heels” of depleted UF_6 . The resulting aqueous wash solution would be evaporated and converted to solid U_3O_8 and HF. The U_3O_8 would be packaged and sent for disposal. The HF would be neutralized to CaF_2 and separately packaged for either disposal or sale.

Construction of the cylinder treatment facility would generate both hazardous and nonhazardous wastes. These waste quantities — hazardous, 18 m^3 ; solid nonhazardous, 300 m^3 ; and sanitary and other nonhazardous liquids, 28,000 m^3 — all represent only minimal waste management impacts for the Paducah site. No radioactive waste would be generated during construction of this facility.

The amounts of waste generated annually during operation of the cylinder treatment facility are given in Table 5.26. Included are crushed old cylinders and wastes obtained (U_3O_8 and CaF_2) from disposal of the “heels.” All of these wastes, except the crushed old cylinders, represent only negligible impacts to the waste management system. Over 20 years of operations, the crushed old cylinders (2,322 cylinders/yr) would generate about 125,000 m^3 ($6,190 \text{ m}^3/\text{yr} \times 20 \text{ years}$) of waste volume for disposal. It was assumed that the treated cylinders with a very low residual radiation level would become part of the DOE scrap metal inventory. If a disposal decision were made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume.

5.3.7.5 Summary

The impacts from the uranium metal conversion facility would be greater than the waste management impacts resulting from operations of U_3O_8 conversion, unless CaF_2 required disposal as a waste. In the latter case, the impacts to waste management facilities for U_3O_8 conversion would probably exceed those for uranium metal conversion. The largest waste volumes would result from conversion to UO_2 .

TABLE 5.26 Annual Waste Generation during Operation of the Cylinder Treatment Facility

Waste Category	Volume (m^3/yr)
Low-level waste	
Combustible solids	31
Contaminated metal and other noncombustible solids	11
U_3O_8	6.3
Low-level mixed waste	0.2
Hazardous waste	2
Nonhazardous waste	
Solids	100
Wastewater	6,400
CaF_2	14
Sanitary waste	2,300
Crushed cylinders	6,190

5.3.8 Resource Requirements

The approach taken for assessment of resource requirements was based on a comparison of required resources with national and county-level statistics on consumption of commodities (U.S. Department of Commerce 1997, 1999). More detailed information relating to the methodology is presented in Appendix C of the PEIS.

Utilities and materials required for constructing the conversion facility for UF_6 to U_3O_8 , UO_2 , or uranium metal are listed in Table 5.27. The equipment for conversion processes would be purchased from equipment vendors. The total quantities of commonly used materials of construction (e.g, carbon steel, stainless steel) for equipment would be minor compared to the quantities required

TABLE 5.27 Resource Requirements for Constructing a Conversion Facility

Utilities/Materials	Unit	Total Consumption		
		Conversion to U ₃ O ₈	Conversion to UO ₂	Conversion to Metal
Utilities				
Electricity ^a	MWh	30,000	35,000	35,000 – 45,000
Solids				
Concrete	yd ³	15,000 – 18,000	21,000 – 44,300	20,000 – 23,000
Steel (carbon or mild)	ton	6,000 – 7,000	8,000 – 8,800	9,000 – 10,000
Liquids				
Diesel fuel	million gal	0.75	0.45 – 0.80	0.80 – 1.0
Gasoline	million gal	0.75	0.40 – 0.80	0.80 – 1.0
Gases				
Industrial gases (propane)	gal	4,000	4,400	4,400 – 5,500
Specialty materials				
Monel	ton	15 – 30	25 – 88	20 – 100
Inconel	ton	10	10 – 88	0 – 4
Titanium	ton	NA ^b	0 – 33	0 – 10

^a The peak electricity demand during any hour would be as follows: conversion to U_3O_8 , about 1.5 MW; conversion to UO_2 , about 1.5 MW; conversion to metal, from 1.5 to 2.5 MW.

^b NA = not applicable.

Source: LLNL (1997).

for facility construction, as listed in Table 5.27. The primary specialty materials required for fabricating process equipment include Monel and Inconel (LLNL 1997). Utilities and materials required for operating the three types of conversion facilities are shown in Table 5.28.

5.3.9 Land Use

5.3.9.1 Conversion to U_3O_8

Impacts to land use from the construction and operation of a U_3O_8 conversion facility at the Paducah site would generally be negligible. Such impacts would be limited to the clearing of required land, minor and temporary disruptions to contiguous land parcels, and a slight increase in vehicular traffic. Under this conversion option, a conversion facility would require approximately 20 acres (8 ha) for construction and about 13 acres (5 ha) for operation (see Table 5.29). The construction phase requires more land because space is needed for material excavation storage, equipment staging, and construction material laydown areas. These land areas constitute less than 1% of the land area of the Paducah site.

The amount of land required for this conversion option would not be great enough to require major land modification. However, it should be noted that siting a conversion facility at a location within the site that has been previously disturbed or used industrially could result in fewer land-use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

Impacts to land use outside the boundaries of a conversion facility would include negligible and temporary traffic impacts associated with project construction peaks. Also, because of the handling of UF_6 at the facility, NUREG-1140 (McGuire 1985) suggests that a 1-mile protective action distance be established around such a facility, which would cover an area of about 960 acres. The protective action distance is the recommended distance for which emergency planning would be appropriate to mitigate off-site exposure to accidental releases.

5.3.9.2 Conversion to UO_2

Impacts to land use from the UO_2 conversion option would be slightly greater than those associated with other conversion options. The areal requirements for this option range from 22 to 31 acres (9 to 13 ha) for construction and from 14 to 20 acres (5.5 to 8 ha) for operations (Table 5.29), still less than 1% of the land area of the Paducah site. Siting a conversion facility at a location within the site that has been previously disturbed or used industrially could result in fewer land-use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

TABLE 5.28 Resource Requirements for Operating a Conversion Facility

Utilities/Materials	Unit	Average Annual Requirement		
		Conversion to U ₃ O ₈	Conversion to UO ₂	Conversion to Metal
Utilities				
Electricity ^a	GWh	11.0	24 – 29	25 – 44
Liquid fuel	gal	6,000	3,040 – 7,000	6,500 – 9,500
Natural gas	million scf ^b	102 – 118	38 – 116	100 – 167
Solids				
Calcium hydroxide (hydrated lime)	million lb	0.388 – 1.27	0.388 – 1.27	0.247
Calcium oxide (quicklime)	million lb	0 – 29	0 – 29	NA ^c
Cement	lb	0 – 862,000	0 – 862,000	0 – 940,000
Detergent	lb	500	600	600 – 700
Iron	million lb	NA	NA	0 – 1.3
Magnesium	million lb	NA	NA	8.4 – 8.6
Sodium chloride	lb	NA	NA	0 – 514,000
Pelletizing lubricant	lb	NA	236,000	NA
Liquids				
Ammonia	million lb	0 – 0.662	2.9	2.4
Hydrochloric acid	lb	11,100 – 18,200	8,900 – 13,600	5,300 – 9,500
Nitric acid	lb	NA	NA	0 – 230,000
Sodium hydroxide	lb	8,800 – 14,400	7,000 – 10,700	4,200 – 7,500

^a Peak electricity demand during any hour would be as follows: conversion to U₃O₈, about 1.5 MW; conversion to UO₂, from 3.2 to 4.0 MW; conversion to metal, from 3.3 to 6.0 MW.

^b scf = standard cubic feet measured at 14.7 lb/in.² absolute (psia) and 60°F.

^c NA = not applicable.

Source: LLNL (1997).

Impacts to local traffic patterns outside potential UO₂ conversion plant sites could be greater than those expected under the conversion to U₃O₈ option due to the potential for increased traffic volume associated with greater construction workforce demands. However, such impacts would be temporary and would be expected to diminish during the operations phase. The protective action distance described in Section 5.3.9.1 would be applicable to an area of about 960 acres around the facility.

**TABLE 5.29 Land Requirements
for the Conversion Options**

Option	Land Requirement (acres) ^a	
	Construction	Operation
Conversion to U ₃ O ₈	20	13
Conversion UO ₂	22 – 31	14 – 20
Conversion to metal	23 – 26	15 – 16

^a NUREG-1140 (McGuire 1985) suggests that each conversion facility establish a protective action distance for emergency planning, which would incorporate an area of about 960 acres around each facility.

Source: LLNL (1997).

5.3.9.3 Conversion to Metal

Land-use impacts at the Paducah site from the conversion to uranium metal option would be minimal. Land requirements (Table 5.29) would be similar to those discussed for the conversion to UO₂ option, and impacts related to construction traffic outside the conversion plant sites would be negligible. The protective action distance would be applicable to an area of about 960 acres around the facility.

5.3.9.4 Cylinder Treatment Facility

Impacts to land use from the construction and operation of a cylinder treatment facility would be negligible and of a lesser magnitude than those generated under any of the conversion options. Although the cylinder treatment facility could be a stand-alone facility, it is likely to be integrated into a depleted UF₆ conversion facility. If the cylinder treatment facility were incorporated into a conversion facility, it would require less than 1 acre (0.4 ha) of additional land, regardless of the conversion option.

As a stand-alone facility, the cylinder treatment facility would require 9 acres (3.5 ha) of land for construction and about 5 acres (2 ha) for operations. The areal requirement would not be

large enough to result in any but minor land-use impacts, particularly if the facility was sited at a location already dedicated to a similar industrial-type use.

5.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the conversion options considered in this report were implemented include impacts to cultural resources and environmental justice, as well as impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of the conversion facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts (e.g., impacts on cultural resources, threatened and endangered species, wetlands, and environmental justice) could not be determined at the programmatic level without considering specific locations for construction within the Paducah site, which are not currently known. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific locations are considered.
- Consideration of these impacts would not contribute to differentiation among the alternatives and, therefore, would not affect the decisions to be made in the ROD for the PEIS.

5.4 POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH CONVERSION OF THE ENTIRE CYLINDER INVENTORY AT THE PADUCAH SITE

After the draft PEIS was completed, management responsibility for approximately 11,200 additional cylinders of depleted UF_6 was transferred from USEC to DOE by the signing of two MOAs associated with the privatization of USEC (DOE and USEC 1998a,b). To account for uncertainties associated with the number of cylinders that would be transferred from USEC to DOE in the future and to provide a bounding analysis of environmental impacts for the purpose of analysis, the depleted UF_6 PEIS analyzed the environmental impacts of managing an additional 15,000 cylinders. These analyses are summarized in Chapter 6 of the PEIS; impacts associated with conversion of the entire inventory (including USEC cylinders) at the Paducah site are summarized in this section.

5.4.1 Approach Used to Evaluate the Environmental Impacts of Conversion for the Entire Cylinder Inventory

To account for the additional USEC-generated cylinders in the conversion options, the basic facility designs were assumed to remain the same, but the facilities were assumed to operate over a longer period of time. It was assumed that the period for operations would be extended by about 6 years to accommodate the additional USEC-generated cylinders (i.e., from 20 to 26 years). Under this assumption, annual impacts would generally remain the same as those reported on in Section 5.3, although the total impacts would generally increase by about 30%.

5.4.2 Potential Environmental Impacts from Conversion of the Entire Cylinder Inventory (DOE- and USEC-Generated Cylinders)

5.4.2.1 Human Health and Safety — Normal Operations

5.4.2.1.1 Workers

In general, the average annual radiation dose to individual workers associated with conversion of the additional USEC cylinders would be the same as that for DOE-generated cylinders reported on in Section 5.3.1 (i.e., well within applicable standards) because at conversion facilities, the annual worker activities would be the same, but the facilities would operate over a longer period of time. The total doses and numbers of LCFs for involved and noninvolved workers would be increased by about 30% (see values in brackets in Table 5.2).

Hazard indices for exposure to chemicals would not change from those presented in Table 5.6 (maximum of 1.2×10^{-6} for noninvolved workers), because annual emissions would not change.

5.4.2.1.2 General Public

For conversion options, the annual dose to the general public MEI reported in Table 5.2 would not change with the addition of the USEC cylinders. The total collective dose to the general public would increase by about 30% (see values in brackets in Table 5.2).

No chemical impacts to the general public would be associated with the increased cylinder inventory. The estimated maximum hazard index for the general public MEI of 0.0001 given in Table 5.6 would not change; this level is far below the threshold level for adverse effects.

5.4.2.2 Human Health and Safety — Accident Conditions

5.4.2.2.1 Physical Hazards

The total number of worker fatalities and injuries associated with conversion options would increase by about 30% with the addition of the USEC cylinders (see values in brackets in Table 5.2).

5.4.2.2.2 Accidents Involving Releases of Radiation or Chemicals

For accident consequences, impacts would be the same as those previously discussed for the DOE-generated cylinders (Section 5.3.2), because the types of accidents assessed would involve only a limited amount of material that would be at risk under accident conditions. Although the estimated frequencies of some accidents would increase somewhat in association with the additional USEC-generated cylinders, this increase is not expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used in the PEIS.

5.4.2.3 Air Quality

At oxide or metal conversion facilities, annual criteria pollutant emissions from construction and operation would be identical to those discussed for DOE-generated cylinders in Section 5.3.3, because conversion facilities would not increase in size, only in duration of operations. For oxide conversion options, an additional 12 to 66 lb (5 to 30 kg) of uranium (as U_3O_8 or UO_2) would be emitted during 6 additional years of operations. For metal conversion options, an additional 24 to 66 lb (11 to 30 kg) of uranium (as U_3O_8 or UF_4) would be emitted during 6 additional years of operations. The total uranium emissions that would result from conversion of both the DOE- and USEC-generated inventory could range from about 52 to 290 lb (24 to 132 kg) for oxide conversion options and from about 100 to 290 lb (45 to 130 kg) for metal conversion options. No air quality standards exist for uranium compounds. However, the potential health impacts from these emissions were evaluated in Sections 5.4.2.1 and 5.4.2.2.

5.4.2.4 Water and Soil

The amount of water used to construct conversion facilities would be the same as discussed for DOE-generated cylinders in Section 5.3.4. The duration of operational activities at conversion facilities would increase by 6 years, resulting in an additional water requirement of about 200 to 1,700 million gal for oxide conversion options and about 330 million gal for metal conversion options. About 90–840 million gal and 150–180 million gal of additional wastewater would be

generated for the oxide and metal conversion options, respectively. The total water requirements would be about 880–7,400 million gal for oxide conversion and 1,400 million gal for metal conversion; the total wastewater generated would be about 390–3,600 million gal for oxide conversion and 650–780 million gal for metal conversion.

Impacts to surface water and groundwater from conversion facilities would partially depend on the actual location within the Paducah site. On the basis of the assessment in Section 5.3.4, impacts from the DOE cylinders only were expected to be negligible. Additional impacts to surface water, groundwater, or soil as a result of conversion of the additional USEC-generated cylinders would also probably be negligible because annual emissions would not change.

5.4.2.5 Socioeconomics

The annual socioeconomic impacts from operating a conversion facility would be the same as those estimated for the DOE-generated cylinders in Section 5.3.5, but the period of operation would be extended by 6 years. Annual socioeconomic impacts during construction would also be the same as those for managing DOE-generated cylinders.

5.4.2.6 Ecology

At a conversion facility, the processing of USEC-generated cylinders would not result in any additional land use requirements or habitat loss, because the size of the conversion facility would not change. Impacts would remain as discussed in Section 5.3.6.

5.4.2.7 Waste Management

The duration of operational activities at a U_3O_8 conversion facility would be increased by 6 years, resulting in the generation of about 1,100 to 4,700 yd³ (840 to 3,600 m³) of additional LLW, 8 yd³ (6 m³) of additional LLMW, and 55 yd³ (42 m³) of additional hazardous waste. For conversion to UO_2 , about 1,300 to 5,800 yd³ (1,000 to 4,400 m³) of additional LLW, 0 to 1,400 yd³ (0 to 1,100 m³) of additional LLMW, and 55 to 130 yd³ (42 to 100 m³) of additional hazardous waste would be generated. The construction impacts would be the same as those presented for DOE-generated cylinders in Section 5.3.7. For conversion to U_3O_8 , the total waste generated during operations (USEC and DOE-generated material) would be about 4,700 to 21,000 yd³ (3,600 to 16,000 m³) of LLW, 34 yd³ (26 m³) of LLMW, and 240 yd³ (180 m³) of hazardous waste. For conversion to UO_2 , the total waste generated during operations (USEC and DOE-generated material) would be about 5,800 to 25,000 yd³ (4,400 to 19,000 m³) of LLW, 0 to 620 yd³ (0 to 470 m³) of

LLMW, and 240 to 580 yd³ (180 to 440 m³) of hazardous waste. (The ranges are the result of assessing different conversion technologies.)

If CaF₂ was produced in the conversion to oxide process, and if the CaF₂ was disposed of as nonradioactive, nonhazardous, solid waste, an additional 3,000 to 87,000 yd³ (2,300 to 66,000 m³) of nonradioactive, nonhazardous solid waste would be generated over the additional 6 years of operation. The capacity for managing this annual volume of nonhazardous waste would already be in place. If the CaF₂ was disposed of as LLW, an additional 170,000 yd³ (128,000 m³) of LLW would be generated over the additional 6 years of operation. (The additional volume would be the result of grouting.) In total, about 720,000 yd³ (550,000 m³) of CaF₂ LLW could be generated as a result of conversion to oxide. This quantity would represent about 13% of the projected DOE complexwide disposal volume for approximately the same time period, an amount that would represent a moderate impact on waste management if the LLW was considered to be DOE waste.

At a metal conversion facility, the impacts during construction would be the same as those for DOE-generated cylinders described in Section 5.5.7. Operation of the metal conversion facility would increase by 6 years, so about 1,400 to 14,000 yd³ (1,100 to 11,000 m³) of additional LLW, 8 yd³ (6 m³) of additional LLMW, and 55 to 78 yd³ (42 to 60 m³) of additional hazardous waste would be generated as a result of including the USEC-generated cylinders. The total waste generated during operations for conversion of both DOE- and USEC-generated cylinders would be about 6,400 to 64,000 yd³ (4,900 to 49,000 m³) of LLW, 34 yd³ (26 m³) of LLMW, and 230 to 340 yd³ (180 to 260 m³) of hazardous waste. (The ranges are the result of assessing different conversion technologies.)

If MgF₂ produced in the metal conversion process was disposed of as nonradioactive, nonhazardous, solid waste, an additional 48,000 yd³ (37,000 m³) of nonradioactive, nonhazardous, solid waste would be generated. This additional waste would be disposed of annually (about 7,900 yd³ [6,100 m³] per year) over the additional 6 years of operation of the conversion facility. The capacity for managing this annual volume of nonhazardous waste would already be in place. If the MgF₂ needed to be disposed of as LLW, an additional 96,000 yd³ (74,000 m³) of LLW would be generated over the additional 6 years of operation. This additional volume would be a result of grouting. In total, about 420,000 yd³ (320,000 m³) of MgF₂ LLW could be generated through conversion to metal. This amount of LLW would represent less than 8% of the projected DOE complexwide disposal volume for approximately the same time period, which would be considered a low impact for waste management if the LLW was considered DOE waste. If HF was neutralized to produce CaF₂, and if the CaF₂ needed to be disposed of as LLW, an additional 27,000 yd³ (21,000 m³) of CaF₂ would be produced, yielding a total of 120,000 yd³ (91,000 m³) of grouted CaF₂ LLW. This additional volume of LLW would constitute approximately 4% of the projected DOE complexwide LLW disposal volume.

The duration of operational activities at a cylinder treatment facility would increase by 6 years, resulting in a total of about 380 yd³ (290 m³) of additional LLW, 1.6 yd³ (1.2 m³) of additional LLMW, and 16 yd³ (12 m³) of additional hazardous waste generated as a result of the inclusion of the USEC-generated cylinders. The construction impacts would be the same as those described for management of DOE-generated material. The total waste generated during treatment operations for both DOE- and USEC-generated cylinders would be about 1,600 yd³ (1,200 m³) of LLW, 6.8 yd³ (5.2 m³) of LLMW, and 68 yd³ (52 m³) of hazardous waste. The crushed cylinders, totaling about 37,000 m³, would add an additional 1% to the projected DOE complexwide LLW disposal volume (if a decision for disposal was made). The total inventory of crushed cylinders would add an additional 4% to the projected DOE complexwide LLW disposal volume.

5.4.2.8 Resource Requirements

In general, the addition of the USEC cylinders would not change the impact assessment for resource requirements for conversion activities. The construction requirements identified in Section 5.3.8 would remain the same. The annual resource requirements identified in Table 5.28 would be extended for an additional 6 years. No significant impacts would be expected, because construction and operational requirements would not be resource intensive, and the resources required would not be rare or unique.

5.4.2.9 Land Use

The land use required for conversion facilities would be the same as that for management of DOE-generated cylinders only described in Section 5.3.9, because the facility sizes would remain the same.

5.4.2.10 Cultural Resources

Impacts to cultural resources from a conversion facility at the Paducah site cannot be determined at this time and would depend on the exact location within the site and whether eligible cultural resources existed on or near that location.

5.4.2.11 Environmental Justice

Potential environmental justice impacts to minority and low-income populations from the construction and operation of conversion facilities would depend on the locations of these facilities within the Paducah site. Although these specific locations are not known, no disproportionately high

and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah site in association with the conversion for the entire cylinder inventory (DOE- and USEC-generated cylinders), because impacts from conversion activities did not exceed the screening criteria for adverse impacts outlined in Section C.8.2.3 of the PEIS.

6 ENVIRONMENTAL IMPACTS OF OPTIONS FOR LONG-TERM STORAGE AS UF_6 AND URANIUM OXIDE AT THE PADUCAH SITE

Storage of the depleted uranium is defined as holding the material for a temporary period, after which it is either converted to another chemical form, used, disposed of, or stored elsewhere. Storage options would preserve access to the depleted uranium for use at a later date by storing it in a retrievable form in a facility designed for indefinite, low-maintenance operation.

The storage options in the PEIS are defined by the chemical form of the depleted uranium stored and the type of storage facility. Depleted uranium could be stored as UF_6 , or, following chemical conversion, as U_3O_8 or UO_2 . Storage as UF_6 would take place in cylinders similar to those currently used, whereas U_3O_8 or UO_2 would be stored in drums. Different types of storage facilities are considered for each chemical form (summarized in Table 6.1). For storage of UF_6 cylinders, the storage options considered include outdoor yards and aboveground buildings. For storage of U_3O_8 and UO_2 in drums, the storage options include aboveground buildings and belowground vaults. Each type of storage facility is described in Section 6.3.

The choice of the chemical form of the depleted uranium for storage would depend in part on the desired end use or disposition of the material. For instance, storage in the form of UF_6 would provide maximum flexibility for future uses; however, UF_6 is not as chemically stable as other chemical forms because it becomes a gas at relatively low temperatures and is soluble in water. Storage in the form of UO_2 or U_3O_8 is attractive in view of their long-term stability, and may be the form of the material preferred for use as shielding or for disposal.

For this analysis, all storage facilities were assumed to be stand-alone, single-purpose facilities consisting of a central receiving building/warehouse surrounded by storage areas, all within a security fence. The storage facility would be capable of receiving containers of depleted uranium by truck or railcar, inspecting the containers, repackaging the material if necessary, and placing the containers into storage. Depending on the option, containers would be stored in a series of yards, buildings, or vaults. Once placed in storage, the containers of depleted uranium would require only

Storage Options

Depleted uranium could be stored until use at a later date. Storage options are defined by the chemical form of the uranium and the type of storage facility. The following storage options are considered in the PEIS:

Storage as UF_6 . Storage of UF_6 could take place in cylinders similar to those currently used. Storage facilities considered include yards and buildings.

Storage as U_3O_8 . Depleted uranium could be stored in drums as U_3O_8 following conversion. Storage facilities considered for U_3O_8 include buildings and belowground vaults.

Storage as UO_2 . Similar to options for U_3O_8 , depleted uranium could be stored in drums as UO_2 in buildings or belowground vaults.

TABLE 6.1 Summary of Depleted Uranium Chemical Forms and Storage Options Considered

Chemical Form	Storage Option Considered		
	Yards	Buildings	Vaults
UF ₆	Yes	Yes	No
U ₃ O ₈	No	Yes	Yes
UO ₂	No	Yes	Yes

routine monitoring and maintenance activities. The containers would be routinely inspected for damage or corrosion, the air would be monitored for indications of releases that would signify the presence of damaged containers, and any damaged containers would be repaired or replaced. The storage facilities would be designed to protect the stored material from the environment and prevent potential releases of material to the environment.

Potential environmental impacts would occur during (1) construction of a storage facility, (2) routine storage facility operations, and (3) potential storage accidents. The potential impacts during construction are generally limited to the duration of the construction period and result from typical land-clearing and construction activities. Potential impacts during operations would result primarily from the handling and inspection of containers. Impacts could also occur from potential accidents that release hazardous materials to the environment.

In general, the environmental impacts from the storage options were evaluated on the basis of information described in the engineering analysis report (LLNL 1997). For each storage option except storage as UF₆ in yards, the engineering analysis report provided preconceptual facility design data, including descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and estimates of potential accident scenarios. The design of facilities required for UF₆ storage in yards was partially based on current yard storage practices (Parks 1997), as well as the designs for building storage of UF₆ presented in the engineering analysis report (LLNL 1997). The assessment considers storage of depleted uranium through the year 2039. Storage facilities were assumed to receive containers of DOE-generated depleted uranium over a 20-year period beginning in 2009 and store the material for a period of 11 years after receipt of the last container.

In the PEIS, the analyses of the long-term storage options assumed that the three current storage sites were representative of sites that might actually be used for these activities. Analyses were conducted by using site-specific data for each of the three current storage sites (Paducah, Portsmouth, and K-25). After the analyses were completed, the results were aggregated and

presented as a range that accounted for differences in the sites as well as differences in technologies that might be used in the future. For this report, ranges of impacts from the different long-term storage technologies examined in the PEIS are presented specifically for the Paducah site. Although the analyses for long-term storage used some data for the Paducah site, these analyses are not sufficient to completely fulfill NEPA requirements for site-specific environmental analyses for an actual conversion or long-term storage facility. For such analyses, detailed technology design and effluent data and data on the exact location within the Paducah site where the facilities would be located must be available.

6.1 SUMMARY OF STORAGE OPTION IMPACTS

Potential environmental impacts for the storage options, with the Paducah site used as a representative location, are summarized in Table 6.2. A more detailed assessment of specific storage technologies and site conditions will be conducted as appropriate as part of the second tier of the NEPA process.

After the draft PEIS was completed, management responsibility for approximately 11,200 additional cylinders of depleted UF_6 was transferred from USEC to DOE. To provide a bounding analysis of environmental impacts, the depleted UF_6 PEIS evaluated the environmental impacts of managing an additional 15,000 cylinders. The impacts associated with long-term storage of the total inventory (including USEC-generated cylinders) are summarized in Section 6.4. A summary of the estimated environmental impacts associated with conversion of the DOE-generated cylinders only and the total cylinder inventory (DOE-generated plus USEC-generated) is presented in Table 6.2.

The following general conclusions can be drawn from the summary table:

- The environmental impacts from storage tend to be small for all chemical forms and types of storage facilities.
- For storage as UF_6 , yard storage has slightly greater environmental impacts than storage in buildings.
- For storage as U_3O_8 , the environmental impacts tend to be similar among buildings and vaults.
- For storage as UO_2 , the environmental impacts tend to be similar among buildings and vaults.
- The differences in impacts among chemical forms are partially related to differences in material bulk densities, with denser material, such as UO_2 , requiring less storage space. UF_6 storage impacts also consider the greater

TABLE 6.2 Summary of Long-Term Storage Option Impacts for the Paducah Site^a**A. UF₆**

Impacts from Storage as UF ₆ in Yards	Impacts from Storage as UF ₆ in Buildings
<i>Human Health – Normal Operations: Radiological</i>	
Involved Workers: Total collective dose: 680 person-rem [880 person-rem]	Involved Workers: Total collective dose: 240 person-rem [310 person-rem]
Total number of LCFs: 0.3 LCF [0.4 LCF]	Total number of LCFs: 0.1 LCF
Noninvolved Workers: Negligible impacts	Noninvolved Workers: Negligible impacts
General Public: Negligible impacts	General Public: Negligible impacts
<i>Human Health – Normal Operations: Chemical</i>	
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts
<i>Human Health – Accidents: Radiological</i>	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 5.3 person-rem Number of LCFs: 2×10^{-3}	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 5.3 person-rem Number of LCFs: 2×10^{-3}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 9 person-rem Number of LCFs in population within 50 miles: 5×10^{-3} LCF	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 9 person-rem Number of LCFs in population within 50 miles: 5×10^{-3} LCF

TABLE 6.2 (Cont.)

Impacts from Storage as UF ₆ in Yards	Impacts from Storage as UF ₆ in Buildings
Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 450 persons	Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 450 persons
Number of persons with potential for irreversible adverse effects: 330 persons	Number of persons with potential for irreversible adverse effects: 330 persons
General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 2,500 persons	Number of persons with potential for adverse effects: 2,500 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
Human Health — Accidents: Physical Hazards	
Construction and Operations: All Workers: 0.1 [0.13] fatality, approximately 92 [120] injuries	Construction and Operations: All Workers: 0.25 [0.33] fatality, approximately 150 injuries
Air Quality	
Construction: 24-hour PM ₁₀ concentration potentially as large as 20% of standard; concentrations of other criteria pollutants below 2% of respective standards	Construction: Annual NO _x concentration potentially as large as 3% of standard; concentrations of other criteria pollutants 1% or less of respective standards
Operations: 24-hour PM ₁₀ concentration potentially as large as 11% of standard; concentrations of other criteria pollutants below 0.6% of respective standards	Operations: Concentrations of all criteria pollutants 0.2% or less of respective standards

TABLE 6.2 (Cont.)

Impacts from Storage as UF ₆ in Yards	Impacts from Storage as UF ₆ in Buildings
<i>Water</i>	
Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater
<i>Soil</i>	
Construction: Moderate, but temporary, impacts	Construction: Moderate, but temporary, impacts
Operations: No impacts	Operations: No impacts
Excavation of Soil: Change in topography from 256,000 yd ³ [323,000 yd ³] of excavated material	Excavation of Soil: Change in topography from 157,000 yd ³ [211,000 yd ³] of excavated material
<i>Socioeconomics^b</i>	
Jobs: 100 peak year, construction; 50/year over 30 years, operations [60/year over 30 years, operations]	Jobs: 200 peak year, construction, 50/year over 30 years, operations [60/year over 30 years, operations]
Income: \$5 million peak year, construction; \$3 million/year over 30 years, operations [\$4 million/year over 30 years, operations]	Income: \$9 million peak year, construction, \$3 million/year over 30 years, operations [\$4 million/year over 30 years, operations]
Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances
<i>Ecology</i>	
Loss of 144 acres [170 acres]; potentially moderate to large impacts to vegetation and wildlife	Loss of 131 acres [165 acres] acres; potentially moderate to large impacts to vegetation and wildlife
<i>Waste Management</i>	
Construction: Negligible to moderate, but temporary, impacts (solid waste)	Construction: Negligible to moderate, but temporary, impacts (solid waste)
Operations: Negligible impacts (all waste forms)	Operations: Negligible impacts (all waste forms)
<i>Resource Requirements</i>	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected

TABLE 6.2 (Cont.)

Impacts from Storage as U ₃ O ₈ in Buildings	Impacts from Storage as U ₃ O ₈ in Vaults
<i>Land Use</i>	
Use of approximately 144 acres [170 acres]; potential moderate impacts	Use of approximately 131 acres [165 acres]; potential moderate impacts
<hr/>	
B. U₃O₈	
<i>Human Health – Normal Operations: Radiological</i>	
Involved Workers:	Involved Workers:
Total collective dose:	Total collective dose:
940 person-rem	940 person-rem
[1,200 person-rem]	[1,200 person-rem]
Total number of LCFs:	Total number of LCFs:
0.4 LCF	0.4 LCF
[0.5 LCF]	[0.5 LCF]
Noninvolved Workers:	Noninvolved Workers:
Negligible impacts	Negligible impacts
General Public:	General Public:
Negligible impacts	Negligible impacts
<hr/>	
<i>Human Health – Normal Operations: Chemical</i>	
Noninvolved Workers:	Noninvolved Workers:
No impacts	No impacts
General Public:	General Public:
No impacts	No impacts
<hr/>	
<i>Human Health – Accidents: Radiological</i>	
Bounding accident frequency:	Bounding accident frequency:
1 in 10,000 years to 1 in 1 million years	1 in 10,000 years to 1 in 1 million years
Noninvolved Workers:	Noninvolved Workers:
Bounding accident consequences (per occurrence):	Bounding accident consequences (per occurrence):
Dose to MEI: 7.4 rem	Dose to MEI: 7.4 rem
Risk of LCF to MEI: 3×10^{-3}	Risk of LCF to MEI: 3×10^{-3}
Collective dose: 300 person-rem	Collective dose: 300 person-rem
Number of LCFs: 0.1	Number of LCFs: 0.1
<hr/>	

TABLE 6.2 (Cont.)

Impacts from Storage as U ₃ O ₈ in Buildings	Impacts from Storage as U ₃ O ₈ in Vaults
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 4 person-rem Number of LCFs in population within 50 miles: 2×10^{-3} LCF	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 4 person-rem Number of LCFs in population within 50 miles: 2×10^{-3} LCF
Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years Noninvolved Workers: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 persons Number of persons with potential for irreversible adverse effects: 0 persons General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 persons Number of persons with potential for irreversible adverse effects: 0 persons	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years Noninvolved Workers: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 persons Number of persons with potential for irreversible adverse effects: 0 persons General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 persons Number of persons with potential for irreversible adverse effects: 0 persons
Human Health — Accidents: Physical Hazards	
Construction and Operations: All Workers: 0.29 [0.38] fatality, approximately 165 [220] injuries	Construction and Operations: All Workers: 0.26 [0.34] fatality, approximately 151 [200] injuries
Air Quality	
Construction: Annual NO _x concentration potentially as large as 2.2% of standard; all other criteria pollutant concentrations less than 0.7% of respective standards Operations: Concentrations of all criteria pollutants less than 0.2% of respective standards	Construction: Annual NO _x concentration potentially as large as 13% of standard; all other criteria pollutant concentrations less than 3% of respective standards Operations: Concentration of all criteria pollutants less than 0.4% of respective standards

TABLE 6.2 (Cont.)

Impacts from Storage as U ₃ O ₈ in Buildings	Impacts from Storage as U ₃ O ₈ in Vaults
<i>Water</i>	
Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater
<i>Soil</i>	
Construction: Moderate, but temporary, impacts	Construction: Moderate, but temporary, impacts
Operations: No impacts	Operations: No impacts
Excavation of Soil: Change in topography from 183,000 yd ³ [228,000 yd ³] of excavated material	Excavation of Soil: Change in topography from 1.7 million yd ³ [2.3 million yd ³] of excavated material
<i>Socioeconomics^b</i>	
Jobs: 170 peak year construction; 60/year over 30 years, operations [70/year over 30 years, operations]	Jobs: 210 peak year, construction; 60/year over 30 years, operations [70/year over 30 years, operations]
Income: \$8 million peak year, construction; \$3 million/year over 30 years, operations [\$4 million/year over 30 years, operations]	Income: \$9 million peak year, construction; \$4 million/year over 30 years, operations [\$5 million/year over 30 years, operations]
Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances
<i>Ecology</i>	
Loss of 148 acres [173 acres]; potentially moderate to large impacts to vegetation and wildlife	Loss of 212 acres [264 acres]; potentially moderate to large impacts to vegetation and wildlife
<i>Waste Management</i>	
Construction: Minimal to moderate, but temporary, impacts (solid waste)	Construction: Minimal to moderate, but temporary, impacts (solid waste)
Operations: Negligible impacts (all waste forms)	Operations: Negligible impacts (all waste forms)
<i>Resource Requirements</i>	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected
<i>Land Use</i>	
Use of approximately 148 acres [173 acres]; potential moderate impacts	Use of approximately 212 acres [264 acres]; potential large impacts, including impacts from disposal of excavated material

TABLE 6.2 (Cont.)**C. UO₂**

Impacts from Storage as UO ₂ in Buildings	Impacts from Storage as UO ₂ in Vaults
<i>Human Health – Normal Operations: Radiological</i>	
Involved Workers: Total collective dose: 540 person-rem [700 person-rem]	Involved Workers: Total collective dose: 540 person-rem [700 person-rem]
Total number of LCFs: 0.2 LCF [0.3 LCF]	Total number of LCFs: 0.2 LCF [0.3 LCF]
Noninvolved Workers: Negligible impacts	Noninvolved Workers: Negligible impacts
General Public: Negligible impacts	General Public: Negligible impacts
<i>Human Health – Normal Operations: Chemical</i>	
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts
<i>Human Health – Accidents: Radiological</i>	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 7.7 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 320 person-rem Number of LCFs: 0.1	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 7.7 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 320 person-rem Number of LCFs: 0.1
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.23 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 4 person-rem Number of LCFs in population within 50 miles: 2×10^{-3} LCF	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.23 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 4 person-rem Number of LCFs in population within 50 miles: 2×10^{-3} LCF

TABLE 6.2 (Cont.)

Impacts from Storage as UO ₂ in Buildings	Impacts from Storage as UO ₂ in Vaults
<i>Human Health – Accidents: Chemical</i>	
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
<i>Human Health — Accidents: Physical Hazards</i>	
Construction and Operations: All Workers: 0.16 [0.21] fatality, approximately 111 [150] injuries	Construction and Operations: All Workers: 0.14 [0.18] fatality, approximately 104 [140] injuries
<i>Air Quality</i>	
Construction: Annual NO _x concentration potentially as large as 2% of standard; all other criteria pollutant concentrations 0.5% or less of respective standards	Construction: Annual NO _x concentration potentially as large as 11% of standard; all other criteria pollutant concentrations 3% or less of respective standards
Operations: Concentration of all criteria pollutants 0.1% or less of respective standards	Operations: Concentrations of all criteria pollutant 0.2% or less of respective standards
<i>Water</i>	
Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater

TABLE 6.2 (Cont.)

Impacts from Storage as UO ₂ in Buildings	Impacts from Storage as UO ₂ in Vaults
Soil	
Construction: Moderate, but temporary, impacts	Construction: Moderate, but temporary, impacts
Operations: No impacts	Operations: No impacts
Excavation of Soil: Change in topography from 81,000 yd ³ [101,000 yd ³] of excavated material	Excavation of Soil: Change in topography from 750,000 yd ³ [1 million yd ³] of excavated material
Socioeconomics^b	
Jobs: 120 peak year, construction; 70/year over 30 years, operations [80/year over 30 years, operations]	Jobs: 140 peak year, construction; 70/year over 30 years, operations [80/year over 30 years, operations]
Income: \$5 million peak year, construction; \$3 million/year over 30 years, operations [\$4 million/year over 30 years, operations]	Income: \$6 million peak year, construction; \$3 million/year over 30 years, operations [\$4 million/year over 30 years, operations]
Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances
Ecology	
Potentially moderate impacts to vegetation and wildlife	Potentially large impacts to vegetation and wildlife
Waste Management	
Construction: Minimal to moderate, but temporary, impacts (solid waste)	Construction: Minimal to moderate, but temporary, impacts (solid waste)
Operations: Negligible impacts (all waste forms)	Operations: Negligible impacts (all waste forms)
Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected
Land Use	
Use of approximately 79 acres [93 acres]; potential moderate impacts	Use of approximately 114 acres [135 acres]; potential moderate impacts

^a In general, the overall environmental consequences from managing the total cylinder inventory (total of USEC-generated and DOE-generated cylinders) are the same as those from managing the DOE-generated cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE cylinders only. LCF = latent cancer fatality, MEI = maximally exposed individual, NO_x = nitrogen oxides, PM₁₀ = particulate matter with a mean diameter of 10 : m or less, ROI = region of influence.

^b For construction, direct jobs and direct income are reported for the peak construction year. For operations, direct jobs and income are presented as annual averages. See Section 6.3.5 for details on indirect impacts in the Paducah site ROI.

reactivity of this form and the small potential for release of HF gas. However, differences in environmental impacts among the forms tend to be small.

6.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the different storage options considered in the assessment of storage impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). That report includes detailed information, such as descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and descriptions of potential accident scenarios.

The chemical form of the depleted uranium (i.e., whether it is UF_6 , U_3O_8 , or UO_2) determines the type of storage container, the total number of containers required, and the storage configuration (the way containers would be stacked). For storage of UF_6 , U_3O_8 , and UO_2 , the following assumptions would apply to all storage facilities:

- The analysis of storage impacts for UF_6 was based on the assumption that UF_6 would be stored in cylinders meeting all applicable storage requirements, either the current cylinders or new cylinders. Cylinder preparation for transportation to a long-term storage site would require thorough inspection of the cylinders to determine that they meet transportation requirements; cylinders not meeting these requirements would be placed in overcontainers for shipment or would have their contents transferred to new cylinders. Cylinder preparation activities were assumed to be carried out so that the cylinders could be delivered to the long-term storage site and placed into storage without further preparation. However, a certain number of cylinders were assumed to be damaged during transport and handling, and the contents of these cylinders were assumed to be transferred to new cylinders at the long-term storage site.
- Depleted UF_6 cylinders would be stacked two high, as is the current practice for outside storage of these cylinders, in rows 1.2 m (4 ft) apart.
- U_3O_8 would be stored in powdered form in 55-gal (210-L) drums, consistent with current practice. Based on a bulk density of about 3 g/cm^3 , the weight of a filled drum would be about 700 kg (1,600 lb). Approximately 714,000 55-gal drums would be required. The drums would be stored in rows of four-drum pallets, two pallets high. The width of each row would be about 1.2 m (4 ft), with 1 m (3 ft) between rows to allow for drum inspections.
- UO_2 would be stored in a sintered form in 30-gal (110-L) drums. Based on a bulk density of sintered UO_2 of about 9 g/cm^3 , a filled 30-gal drum weighs

about 1,100 kg (2,400 lb). Approximately 420,000 30-gal drums would be required. As with U_3O_8 , the drums would be stored in rows of four-drum pallets, two pallets high. The width of each row would be about 1 m (3 ft), with 1 m (3 ft) between rows, to allow for drum inspections.

- For UF_6 cylinders and U_3O_8 and UO_2 drums, the contents of containers damaged during handling and storage would be transferred to new containers (0.7% of the drums containers received annually were assumed to require replacement [LLNL 1997]).

In these configurations, the total area required for storage would range from 131 to 144 acres (53 to 58 ha) for UF_6 , from 148 to 212 acres (60 to 86 ha) for U_3O_8 , and from 79 to 114 acres (32 to 46 ha) for UO_2 . The storage areas differ primarily because the bulk densities differ between the chemical forms. Although the total storage area required differs among chemical forms, the basic designs of the storage facility yards, buildings, and vaults would be similar for each. For instance, buildings of similar type would be used for the storage of UF_6 , U_3O_8 , and UO_2 ; however, 17 buildings would be required for storage of UF_6 cylinders, 20 buildings for storage of U_3O_8 drums, and only 9 buildings for storage of UO_2 drums. Because UF_6 is currently stored in cylinder yards at the three storage sites, long-term storage of UF_6 in cylinder yards at a single, centralized location was also examined.

The following sections provide a summary description of each of the storage options. Note that in addition to the primary storage units, each facility also would have an administration building, a receiving warehouse, a repackaging building (attached to the receiving warehouse), and a workshop. Storage facilities for UF_6 would require a cylinder washing facility to recover the heels from damaged cylinders after the removal of the UF_6 .

6.2.1 Storage in Yards

Only depleted UF_6 would be stored in outdoor yards. Yard construction would be similar to current practice; the yards would consist of an 8-in. (20-cm) stabilized base under a 12-in. (30-cm) nonreinforced concrete pad. Twenty pads with dimensions of approximately 160 m \times 80 m would be required. Additional facilities required for yard storage include a receiving warehouse and repackaging building, a cylinder washing building, and an administration building. Maintenance activities assessed for long-term yard storage are similar to those associated with the continued storage strategy (Parks 1997), and include routine inspections, ultrasonic inspections, valve monitoring and maintenance, and regular painting of the cylinders. The contents of any of the cylinders damaged during handling or storage would be subsequently transferred to new cylinders; the old cylinders would be washed and sent for further disposition.

6.2.2 Storage in Buildings

Storage in buildings is considered for UF_6 , U_3O_8 , and UO_2 . Aboveground buildings would be built on-grade and consist of a concrete slab covered by a steel, preengineered, single-span structure. This type of building is commonly called a “Butler” building. Each building would be approximately 840 ft (260 m) long and 160 ft (50 m) wide, with a height of approximately 20 ft (6 m). The number of buildings required for storage of UF_6 , U_3O_8 , and UO_2 would be 17, 20, and 9, respectively. Construction would follow generally accepted practices. Additional facilities are provided which combine receiving/inspection operations with administration, shipping/unloading capabilities, and permanent monitoring capabilities (to ensure the integrity of the stored containers).

6.2.3 Storage in Vaults

Storage in vaults is considered for U_3O_8 and UO_2 . Belowground vaults are subsurface reinforced concrete structures, 131 ft (40 m) wide \times 266 ft (81 m) long, with a height of approximately 20 ft (6 m). The concrete walls are 1 ft (0.3 m) thick, with a floor slab thickness of 2 ft (0.6 m). The majority of the structure is located underground, with only the roof area above grade. A steel roof supported by trusses is used which can be removed to allow access to the vault by a mobile crane outside the structure. A total of 79 vaults would be required for storage of U_3O_8 , and 35 for storage of UO_2 .

6.2.4 Storage Technologies and Chemical Forms Considered But Not Analyzed

Storage of UF_6 in the potentially moist environment of a belowground vault was not considered due to potential accelerated corrosion of the steel cylinders. In addition, storage as depleted uranium metal was not considered because uranium metal is not as stable as U_3O_8 or UO_2 ; it is subject to surface oxidation.

6.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the storage options, including impacts from construction and facility operations. Detailed information related to the assessment methodologies for each area of impact is provided in Appendix C of the PEIS.

The environmental impacts from the storage options were evaluated based primarily on the information described in the engineering analysis report (LLNL 1997). The following general assumptions apply to storage facility operations:

- The assessment considers storage of depleted uranium through the year 2039.
- Two phases of facility operations are considered. Phase I beginning in 2009 corresponds to the first 20 years, when the facilities would receive UF_6 cylinders or UO_2 or U_3O_8 drums from off-site and place them into storage. Phase II corresponds to the next 11 years, when passive storage of cylinders or drums would take place. (When USEC cylinders are considered, the emplacement period is assumed to extend an additional 6 years through 2034; see Section 6.4.)
- Construction of support buildings and initial storage facilities would begin about 2007, and additional storage facilities would be built as needed throughout Phase I.
- All storage containers would be routinely inspected, and any damaged containers would be replaced.
- UF_6 cylinder content transfers and empty cylinder washing activities would be the only sources of emissions associated with normal (nonaccident) operations. All U_3O_8 and UO_2 drum content transfers would be enclosed mechanical operations that would not involve material releases.

6.3.1 Human Health — Normal Operations

6.3.1.1 Radiological Impacts

Radiation doses to the involved workers would result mainly from external radiation during handling of containers of uranium and during routine inspection of the containers. The doses were estimated on the basis of information on the anticipated worker activities provided in the engineering analysis report (LLNL 1997). The activities covered involved and noninvolved workers combined. Therefore, special attention was given to estimating the number of involved workers, defined as those performing hands-on activities in the storage facility. Because the exact activities to be carried out by each involved worker were not clear at this stage, estimation of the individual dose to each worker was difficult. As a result, only the collective dose and average individual dose were calculated for the involved workers. Spreadsheets listing the worker activities and the corresponding dose rates can be found on disk 3 of Cheng et al. (1997) under the file name store-tm.xls.

Radiation doses to noninvolved workers and the general public would result from release of uranium compounds to the environment. According to the engineering analysis report (LLNL 1997), airborne emissions of depleted uranium would be negligible during normal operations of the storage facilities. Results from water quality analyses (Section 6.3.4) also showed that potential

impacts to surface water would be negligible. Therefore, radiological impacts to noninvolved workers and the off-site general public would be negligible for all storage options.

A discussion of the methodologies used in the radiological impact analysis is provided in Appendix C of the PEIS and Cheng et al. (1997). The estimated results for involved workers are presented in Tables 6.3 and 6.4 for all storage options. The results indicate that average radiation exposure to involved workers would be less than 920 mrem/yr.

6.3.1.1.1 Storage as UF_6

Radiation exposures for involved workers from storage as UF_6 would result mainly from cylinder handling, painting (for storage in yards), repackaging, and surveillance activities. Collective radiological impacts from storage in yards would be more than twice that from storage in buildings. Compared with buildings, storage in yards would require more cylinder inspection and cylinder maintenance (painting) activities to control corrosion in an outdoor environment. The collective dose would range from about 7.6 to 22 person-rem/yr (considering Phase I and Phase II) for a worker population of 19 to 26 individuals. The corresponding number of LCFs among the involved workers would range from 0.003 to 0.009 per year (1 to 3 LCFs over a 300-year period).

The average annual individual doses were obtained by dividing the collective dose by the number of workers. To provide a conservative estimate of doses, the calculations did not consider the implementation of as low as reasonably achievable (ALARA) practices to minimize exposures. Because the exact number of workers required to conduct all types of activities is uncertain at this preliminary stage, the estimated average individual doses also involve a large degree of uncertainty. The estimated average individual dose ranges from 290 to 920 mrem/yr for the storage options, with a corresponding individual risk of a latent cancer fatality of 0.0001 to 0.0004 per year (a chance of about 1 to 4 in 10,000 per year). The average individual dose would be well below the regulatory limit of 5,000 mrem/yr (10 CFR Part 835) and would be smaller than the DOE administrative control limit of 2,000 mrem/yr (DOE 1992).

6.3.1.1.2 Storage as U_3O_8

For storage as U_3O_8 , the worker activities would be expected to be similar among the building and vault storage options. Therefore, radiological impacts to involved workers would be similar for these options. For the options, the estimated collective dose is about 30 person-rem/yr for 25 to 34 workers. The corresponding number of LCFs among workers would be about 0.01 per year (about 1 LCF over a 100-year period).

The estimated average individual dose ranges from about 880 to 910 mrem/yr for the U_3O_8 storage options, with a corresponding individual risk of a latent cancer fatality of 0.0004 per year (a chance of about 1 in 2,000). The average dose would be well below the regulatory dose limit of 5,000 mrem/yr.

TABLE 6.3 Radiological Doses from Long-Term Storage Options under Normal Operations

Option	Dose to Receptor					
	Involved Worker ^a		Noninvolved Worker ^b		General Public ^c	
	Average Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose (mrem/yr)	Collective Dose (person-rem/yr)
<i>Storage as UF₆</i>						
Yards	920	22	~ 0	~ 0	~ 0	~ 0
Buildings	290	7.6	~ 0	~ 0	~ 0	~ 0
<i>Storage as U₃O₈</i>						
Buildings	880	30	~ 0	~ 0	~ 0	~ 0
Vaults	910	30	~ 0	~ 0	~ 0	~ 0
<i>Storage as UO₂</i>						
Buildings	810	17	~ 0	~ 0	~ 0	~ 0
Vaults	670	17	~ 0	~ 0	~ 0	~ 0

^a Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

^b Noninvolved workers are individuals who do not participate in material handling activities and individuals who work on-site but not within the facility. Because negligible airborne emission of radioactive materials would be expected from the storage facility (LLNL 1997), radiation doses to noninvolved workers would be negligible.

^c The off-site general public is defined as residents who live within a radius of 50 miles (80 km) around the storage site. Radiation doses to the off-site public would be negligible because airborne emission of radioactive materials (LLNL 1997) and impacts to surface water quality would be negligible (Section 6.3.4).

TABLE 6.4 Latent Cancer Risks from Long-Term Storage Options under Normal Operations

Option	Latent Cancer Risk to Receptor					
	Involved Worker ^a		Noninvolved Worker ^b		General Public ^c	
	Average Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk (risk/yr)	Collective Risk (fatalities/yr)
<i>Storage as UF₆</i>						
Yards	4×10^{-4}	9×10^{-3}	~ 0	~ 0	~ 0	~ 0
Buildings	1×10^{-4}	3×10^{-3}	~ 0	~ 0	~ 0	~ 0
<i>Storage as U₃O₈</i>						
Buildings	4×10^{-4}	1×10^{-2}	~ 0	~ 0	~ 0	~ 0
Vaults	4×10^{-4}	1×10^{-2}	~ 0	~ 0	~ 0	~ 0
<i>Storage as UO₂</i>						
Buildings	3×10^{-4}	7×10^{-3}	~ 0	~ 0	~ 0	~ 0
Vaults	3×10^{-4}	7×10^{-3}	~ 0	~ 0	~ 0	~ 0

^a Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population.

^b Noninvolved workers are individuals who do not participate in material handling activities and individuals who work on-site but not within the facility. Because negligible airborne emission of radioactive materials would be expected from the storage facility (LLNL 1997), cancer risks to noninvolved workers would be negligible.

^c The off-site general public is defined as residents who live within a radius of 50 miles (80 km) around the storage site. Cancer risks to the off-site public would be negligible because airborne emission of radioactive materials (LLNL 1997) and impacts to surface water quality would be negligible (Section 6.3.4).

Storage as U_3O_8 would result in greater collective exposures for involved workers than storage as UF_6 or UO_2 because a larger number of containers would be needed for U_3O_8 than for UF_6 and UO_2 . Consequently, the number of operations for transferring containers, retrieving damaged containers, and surveying the stored inventory would be the greatest for U_3O_8 among the three chemical forms for depleted uranium.

6.3.1.1.3 Storage as UO_2

The storage practices for UO_2 drums would be similar to those for U_3O_8 drums; however, the total number of UO_2 drums would be less than the number of U_3O_8 drums. As a result, the estimated collective exposures to involved workers from drum handling and inspection activities would be less for UO_2 than for U_3O_8 . On the other hand, the number of UO_2 drums would be greater than the number of UF_6 cylinders. Therefore, collective exposures for storage in buildings would be greater for UO_2 than for UF_6 .

Radiological impacts to workers would be similar among the UO_2 storage options. The collective dose to involved workers would be about 17 person-rem/yr for 19 to 26 workers. The corresponding number of latent cancer fatalities among workers would be about 0.007 per year (about 1 LCF over a 140-year period).

The estimated average individual dose ranges from 670 to 810 mrem/yr, with a corresponding individual risk of an LCF of about 0.0003 per year (a chance of about 1 in 2,500). The average dose would be well below the regulatory dose limit.

6.3.1.2 Chemical Impacts

Chemical impacts to the MEI were assessed for noninvolved workers and the public. However, according to the engineering analysis report (LLNL 1997), no airborne emissions of uranium would be expected for long-term storage facilities, and only small quantities of HF would be emitted under the UF_6 storage option. Therefore, the only potential chemical exposures for noninvolved workers and the public that were considered are those that would result from airborne emissions of HF emitted from the cylinder transfer and washing operations. In addition, potential chemical exposures resulting from the storage facilities wastewater emissions were considered for the off-site general public; however, results from water quality analyses (Section 6.3.4.1) showed that potential impacts to surface water bodies would be negligible. Information on the methodologies used for the chemical impact analysis is provided in Appendix C of the PEIS and Cheng et al. (1997).

The results of the analysis of hazardous chemical human health impacts from long-term storage options are summarized in Table 6.5. No impacts on human health from chemical exposures would be expected during normal operations of storage facilities.

TABLE 6.5 Chemical Impacts to Human Health for Long-Term Storage Options under Normal Operations^a

Option	Type	Impacts to Receptor			
		Noninvolved Workers ^a		General Public ^b	
		Hazard Index for MEI ^c	Collective Risk ^d (ind. at risk/yr)	Hazard Index for MEI ^c	Collective Risk ^d (ind. at risk/yr)
Storage as UF ₆	Yards	~ 0	—	~ 0	—
	Buildings	~ 0	—	~ 0	—
Storage as U ₃ O ₈	Buildings	~ 0	—	~ 0	—
	Vaults	~ 0	—	~ 0	—
Storage as UO ₂	Buildings	~ 0	—	~ 0	—
	Vaults	~ 0	—	~ 0	—

^a Noninvolved workers include individuals who work at the facility but are not involved in hands-on activities and individuals who work on-site but not within the facility. Because no airborne emission of uranium and/or very low levels of HF are expected from the storage facility, there would essentially be no noncarcinogenic health impacts to the noninvolved workers.

^b The off-site general public is defined as residents who live with a radius of 50 miles (80 km) around the storage site. There would essentially be no noncarcinogenic health impacts to the general public because no airborne emission of uranium and/or very low levels of HF are expected from the storage facility, there would essentially be no noncarcinogenic health impacts to the noninvolved workers.

^c The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

^d Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

For the long-term storage option, the engineering analysis report (LLNL 1997) assumed that a low percentage of cylinders and drums would require repackaging annually due to handling or corrosion damage. These repackaging operations would result in the only potential releases and exposures to uranium and fluoride compounds for the storage options. For drum repackaging, electrically powered transfer equipment would pour the contents of the damaged drums into new drums, minimizing involved worker contact with the drum contents. The transfer equipment would operate in such a way as to keep the operation enclosed and eliminate dust generation for the U₃O₈ and UO₂ storage forms.

For storage as UF_6 , repackaging would require heating the cylinder in an autoclave and transferring the contents to a new cylinder. A small “heel” of UF_6 (approximately 22 lb [10 kg]) would remain in the emptied cylinder; this material would be removed in the cylinder washing building, converted to UO_2F_2 and CaF_2 , and disposed of. Small amounts of HF would be released from the cylinder washing building stack from the conversion of the UF_6 heels to UO_2F_2 . The maximum annual emission of HF for the Phase I and Phase II operational periods of long-term UF_6 storage would be about 0.10 kg/yr (in yards). In comparison, the maximum estimated annual emission of HF for any of the depleted UF_6 conversion options would be 408 kg/yr. Therefore, the maximum estimated annual emission of HF from any of the UF_6 storage facilities would be more than 4,000 times lower than the maximum annual emission of HF from conversion facilities. Because the results of the conversion analyses (Appendix F of the PEIS) did not indicate any human health impacts and the atmospheric release and transport of HF would occur under similar conditions, the small quantities of HF present in the storage facility emissions would also not result in human health impacts.

For storage as UF_6 , it should also be noted that emissions due to breaches were not assumed because all cylinders would be inspected once every 4 years and would be repackaged immediately if any handling or corrosion damage was identified. Additionally, yard storage assumes that rigorous maintenance would take place, such as ultrasonic test inspections, valve monitoring, and regular painting.

Airborne emissions of depleted uranium are not expected during normal operations of the storage facilities, according to data provided in the engineering analysis report (LLNL 1997). Therefore, no matter which chemical form of depleted uranium is selected, chemical impacts to noninvolved workers and the off-site general public would be negligible.

6.3.2 Human Health — Accident Conditions

For long-term storage as U_3O_8 and UO_2 , a range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents was presented in the engineering analysis report (LLNL 1997). Accidents analyzed for long-term storage in yards were consistent with those analyzed for continued cylinder storage (Section 3), as given in the safety analysis reports (LMES 1997b,e,f). These accidents are listed in Table 6.6. The following sections present the results for radiological and chemical health impacts of the highest consequence accident in each frequency category, with the Paducah site used as representative. Results for all accidents listed in Table 6.6 are presented in Policastro et al. (1997). Detailed descriptions of the methodology and assumptions used in these calculations are also provided in Appendix C of the PEIS and Policastro et al. (1997).

TABLE 6.6 Accidents Considered for the Long-Term Storage Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
<i>Storage as UF₆</i>					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the dry ground.	UF ₆	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF ₆ forming a 4-ft ² area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF ₆ cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF ₆	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF ₆ cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF ₆	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF ₆	4,240 1,190	0 to 30 30 to 121	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
<i>Storage as U₃O₈</i>					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/billet inside the repackaging building	A single U ₃ O ₈ drum is damaged by a forklift and spills its contents onto the ground inside the repackaging building.	U ₃ O ₈	0.00028	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The repackaging building is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	U ₃ O ₈	33	30	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the repackaging building structure and its confinement systems.	U ₃ O ₈	33	0.5	Ground

TABLE 6.6 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level ^a
Storage as U_3O_8 (Cont.)					
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire or explosion inside the repackaging building	A fire or explosion within the repackaging facility affects the contents of a single pallet of drums.	U_3O_8	0.0011	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Storage as UO_2					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/billet inside the repackaging building	A single UO_2 drum is damaged by a forklift and spills its contents onto the ground inside the repackaging building.	UO_2	0.00011	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The repackaging building is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	UO_2	33	30	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the repackaging building structure and its confinement systems.	UO_2	33	0.5	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire or explosion inside the repackaging building	A fire or explosion within the repackaging facility affects the contents of a single pallet of drums.	UO_2	0.00045	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA

^a Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

6.3.2.1 Radiological Impacts

The radiological doses to various receptors for the accidents that would result in the highest dose from each frequency category are listed in Table 6.7. The LCF risks for these accidents are given in Table 6.8. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions were considered for each long-term storage option (see Appendix C of the PEIS). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.
- The maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 7.7 rem. This dose is less than the 25 rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the NRC (1994).
- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table 6.8] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all accidents.

6.3.2.2 Chemical Impacts

The accidents considered in this section are listed in Table 6.6. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables 6.9 and 6.10. The results are presented as (1) number of people with potential for adverse effects and (2) number of people with potential for irreversible adverse effects. The tables present the results for the accident within the frequency category that would affect the largest number of people (total of noninvolved workers and off-site population) (PolICASTRO et al. 1997). The numbers of noninvolved workers and members of the off-site public represent the impacts if the associated accident was assumed to occur. The accidents listed in Tables 6.9 and 6.10 are not identical because an accident with the largest impacts for the adverse effects endpoint might not lead to the largest impacts for the irreversible adverse effects endpoint. The results of the chemical impacts analysis may be summarized as follows:

- If the accidents identified in Tables 6.9 and 6.10 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 2,500 (maximum corresponding to vehicle-induced fire

TABLE 6.7 Estimated Radiological Doses per Accident Occurrence for the Long-Term Storage Options at the Paducah Site

Option/Accident ^a	Frequency Category ^b	Maximum Dose ^c				Minimum Dose ^c			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Storage as UF₆									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	3.2	2.3×10^{-3}	6.1×10^{-2}	3.3×10^{-3}	1.3×10^{-1}	9.8×10^{-5}	7.4×10^{-3}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	5.3	1.5×10^{-2}	9.0	3.7×10^{-3}	5.2×10^{-1}	1.9×10^{-3}	6.3×10^{-1}
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	1.8	4.9×10^{-3}	2.1×10^{-1}	8.7×10^{-4}	2.2×10^{-1}	6.2×10^{-4}	3.0×10^{-2}
Storage as U₃O₈									
Mishandling/drop of drum inside the repackaging building	L	9.4×10^{-9}	2.0×10^{-7}	9.7×10^{-9}	1.8×10^{-6}	2.8×10^{-12}	3.4×10^{-11}	4.8×10^{-10}	9.5×10^{-7}
Earthquake	U	7.4	3.0×10^2	2.2×10^{-1}	4.3	3.1×10^{-1}	1.2×10^1	9.4×10^{-3}	6.4×10^{-1}
Fire or explosion inside the repackaging building	EU	3.6×10^{-8}	7.7×10^{-7}	3.7×10^{-8}	6.7×10^{-6}	1.1×10^{-11}	1.3×10^{-10}	1.8×10^{-9}	3.6×10^{-6}
Storage as UO₂									
Mishandle/drop of drum inside the repackaging building	L	3.7×10^{-9}	8.0×10^{-8}	3.8×10^{-9}	6.9×10^{-7}	1.1×10^{-12}	1.3×10^{-11}	1.9×10^{-10}	3.8×10^{-7}
Earthquake	U	7.7	3.2×10^2	2.3×10^{-1}	4.4	3.2×10^{-1}	1.3×10^1	9.7×10^{-3}	6.7×10^{-1}
Fire or explosion inside the repackaging building	EU	1.5×10^{-8}	3.2×10^{-7}	1.5×10^{-8}	2.8×10^{-6}	4.4×10^{-12}	5.3×10^{-11}	7.5×10^{-10}	1.5×10^{-6}

^a The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^b Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^c Maximum and minimum doses reflect differences in assumed technologies and meteorological conditions at the time of the accident, which is assumed to occur at the center of the site. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

TABLE 6.8 Estimated Radiological Health Risks per Accident Occurrence for the Long-Term Storage Options at the Paducah Site^a

Option/Accident ^b	Frequency Category ^c	Maximum Risk ^d (LCFs)				Minimum Risk ^d (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
<i>Storage as UF₆</i>									
Corroded cylinder spill, dry conditions	L	3 × 10 ⁻⁵	1 × 10 ⁻³	1 × 10 ⁻⁶	3 × 10 ⁻⁵	1 × 10 ⁻⁶	5 × 10 ⁻⁵	5 × 10 ⁻⁸	4 × 10 ⁻⁶
Vehicle-induced fire, 3 full 48G cylinders	EU	8 × 10 ⁻⁶	2 × 10 ⁻³	7 × 10 ⁻⁶	5 × 10 ⁻³	1 × 10 ⁻⁶	2 × 10 ⁻⁴	1 × 10 ⁻⁶	3 × 10 ⁻⁴
Small plane crash, 2 full 48G cylinders	I	3 × 10 ⁻⁶	7 × 10 ⁻⁴	2 × 10 ⁻⁶	1 × 10 ⁻⁴	3 × 10 ⁻⁷	9 × 10 ⁻⁵	3 × 10 ⁻⁷	1 × 10 ⁻⁵
<hr/>									
<i>Storage as U₃O₈</i>									
Mishandle/drop of drum inside the repackaging building	L	4 × 10 ⁻¹²	8 × 10 ⁻¹¹	5 × 10 ⁻¹²	9 × 10 ⁻¹⁰	1 × 10 ⁻¹⁵	1 × 10 ⁻¹⁴	2 × 10 ⁻¹³	5 × 10 ⁻¹⁰
Earthquake	EU	3 × 10 ⁻³	1 × 10 ⁻¹	1 × 10 ⁻⁴	2 × 10 ⁻³	1 × 10 ⁻⁴	5 × 10 ⁻³	5 × 10 ⁻⁶	3 × 10 ⁻⁴
Fire or explosion inside the repackaging building	I	1 × 10 ⁻¹¹	3 × 10 ⁻¹⁰	2 × 10 ⁻¹¹	3 × 10 ⁻⁹	4 × 10 ⁻¹⁵	5 × 10 ⁻¹⁴	9 × 10 ⁻¹³	2 × 10 ⁻⁹
<hr/>									
<i>Storage as UO₂</i>									
Mishandle/drop of drum inside the repackaging building	L	1 × 10 ⁻¹²	3 × 10 ⁻¹¹	2 × 10 ⁻¹²	3 × 10 ⁻¹⁰	4 × 10 ⁻¹⁶	5 × 10 ⁻¹⁵	9 × 10 ⁻¹⁴	2 × 10 ⁻¹⁰
Earthquake	EU	3 × 10 ⁻³	3 × 10 ⁻¹	1 × 10 ⁻⁴	2 × 10 ⁻³	1 × 10 ⁻⁴	5 × 10 ⁻³	5 × 10 ⁻⁶	3 × 10 ⁻⁴
Fire or explosion inside the repackaging building	I	6 × 10 ⁻¹²	1 × 10 ⁻¹⁰	8 × 10 ⁻¹²	1 × 10 ⁻⁹	2 × 10 ⁻¹⁵	2 × 10 ⁻¹⁴	4 × 10 ⁻¹³	8 × 10 ⁻¹⁰

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCFs) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum risks reflect differences in assumed technologies and meteorological conditions at the time of the accident, which is assumed to occur at the center of the site. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

TABLE 6.9 Number of Persons with Potential for Adverse Effects from Accidents under the Long-Term Storage Options at the Paducah Site^a

Option/Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
Storage as UF₆									
Yard									
Corroded cylinder spill, dry conditions	L	Yes	120	No	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	450	Yes	10	Yes _f	52	No	0
Vehicle-induced fire, three full 48G cylinders	EU	Yes	310	Yes	2,500	Yes _f	0	Yes	3
Small plane crash, 48G cylinders	I	Yes	67	Yes	18	Yes _f	0	No	0
Buildings									
Corroded cylinder spill, dry conditions	L	Yes	120	No	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	450	Yes	10	Yes _f	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes _f	0	Yes	3
Small plane crash, 2 full 48G cylinders	I	Yes	67	Yes	18	Yes _f	0	No	0
<hr/>									
Storage as U₃O₈									
Mishandle/drop of drum/cylinder inside ^g	L	No _f	0	No	0	No	0	No	0
Earthquake	U	Yes _f	0	No	0	No	0	No	0
Fire or explosion involving reagent inside ^g	EU	No	0	No	0	No	0	No	0
<hr/>									
Storage as UO₂									
Mishandle/drop of drum/cylinder inside ^g	L	No _f	0	No	0	No	0	No	0
Earthquake	U	Yes _f	0	No	0	No	0	No	0
Fire or explosion involving reagent inside ^g	EU	No	0	No	0	No	0	No	0

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 31 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum values reflect different meteorological conditions at the time of the accident, assumed to occur at the center of the site. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential adverse effects to an individual.

^f MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the site were used, which did not show receptors at the MEI locations.

^g These accidents would result in the largest plume sizes, although no people would be affected.

TABLE 6.10 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Long-Term Storage Options at the Paducah Site^a

Option/Accident ^b	Frequency Category ^c	Maximum Number of Persons ^d				Minimum Number of Persons ^d			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI ^e	Population	MEI ^e	Population	MEI ^e	Population	MEI ^e	Population
<i>Storage as UF₆</i>									
Yard									
Corroded cylinder spill, dry conditions	L	Yes	4	No _f	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	250	Yes _f	0	Yes	4	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	330	Yes _f	0	Yes	7	No	0
Small plane crash, 2 full 48G cylinders	I	No	0	No	0	No	0	No	0
Buildings									
Corroded cylinder spill, dry conditions	L	Yes	4	No _f	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	250	Yes _f	0	Yes	4	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	330	Yes _f	0	Yes	7	No	0
Small plane crash, 2 full 48G cylinders	I	No	0	No	0	No	0	No	0
<hr/>									
<i>Storage as U₃O₈</i>									
Mishandle/drop of drum/cylinder inside ^g	L	No	0	No	0	No	0	No	0
Earthquake	U	No	0	No	0	No	0	No	0
Fire or explosion involving reagent inside ^g	EU	No	0	No	0	No	0	No	0
<hr/>									
<i>Storage as UO₂</i>									
Mishandle/drop of drum/cylinder inside ^g	L	No	0	No	0	No	0	No	0
Earthquake	U	No	0	No	0	No	0	No	0
Fire or explosion involving reagent inside ^g	EU	No	0	No	0	No	0	No	0

^a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

^b The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

^c Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$ /yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$ /yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$ /yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$ /yr).

^d Maximum and minimum values reflect different meteorological conditions at the time of the accident, assumed to occur at the center of the site. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

^e At the MEI location, the determination is either “Yes” or “No” for potential irreversible adverse effects to an individual.

^f MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the site were used, which did not show receptors at the MEI locations.

^g These accidents would result in the largest plume sizes, although no people would be affected.

accident involving three full 48G cylinders), and the number of off-site persons with potential for irreversible adverse effects was estimated to be 0.

- If the accidents identified in Tables 6.9 and 6.10 did occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 450 (maximum corresponding to the corroded cylinder spill accident with rain conditions), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 330 (maximum corresponding to corroded cylinder spill accident with pooling).
- The noninvolved worker population would receive the majority of the severe impacts and the off-site population much less, except for the vehicle-induced fire accident involving three full 48G cylinders. In such case, the plume would rise and hit the ground at distances downwind. The overall risk (frequency times consequence), however, is very low due to the low frequency of occurrence.
- The impacts resulting from the vehicle-induced fire involving three full 48G UF₆ cylinders would be large for members of the general public in terms of potential adverse effects because of the considerable source terms associated with such an accident.
- The overall impact for accidents associated with long-term storage as UF₆ in buildings would be about the same as that associated with storage in a yard. Storage as U₃O₈ would have almost the same impacts as storage as UO₂, with both options having very small impacts compared with the potential impacts for storage as UF₆.
- Stack releases would have much lower impacts than ground-level releases.
- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years in operations (31 years, 2009 through 2039). The results indicated that the maximum risk values would be less than 1 for all accidents except the following:

- *Potential Adverse Effects:*

Corroded cylinder spill, dry conditions (L, likely), workers

Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

- *Potential Irreversible Adverse Effects:*

Corroded cylinder spill, dry conditions (L, likely), workers

Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for noninvolved workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible adverse effects was estimated. All the bounding case accidents shown in Table 6.10 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures would likely be high enough to result in death for 1% or less of the persons experiencing irreversible adverse effects (PolICASTRO et al. 1997). This would mean that for noninvolved workers experiencing a range of 0 to 330 irreversible adverse effects, 0 to about 3 deaths would be expected. No deaths would be expected among the general public. These are the maximum potential consequences of the accidents, the upper ends of the ranges assume worst-case weather conditions and that the wind would be blowing in the direction where the highest numbers of people would be exposed.

6.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries to all long-term storage facility workers is calculated using industry-specific statistics from the Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used respectively for the duration of the construction and operational phases of the facility.

No on-the-job fatalities are predicted for any of the storage options analyzed (range of 0.10 for UF_6 yard storage to 0.29 for U_3O_8 building storage, for the total construction, Phase I operations, and Phase II operations). The range of predicted injuries is about 92 to 165 for the entire facility lifetimes. Physical hazard risks of fatality and injury are presented in Table 6.11 by construction, Phase I, and Phase II components. The largest component of physical hazard risks generally results from construction; in general, construction physical hazard risks are 3 to 4 times greater than risks from Phase I and II operations combined. The overall differences in ranges of physical hazard risks between chemical forms and storage types are fairly small.

For storage as UF_6 , the probability of an on-the-job fatality ranges from 0.10 for storage in yards to 0.25 for storage in buildings — including construction, Phase I, and Phase II of storage. The predicted injury incidence ranges from about 92 to 150 injuries over the lifetime of the facility.

TABLE 6.11 Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Long-Term Storage Options

Option	Impacts to All Long-Term Storage Facility Workers ^a					
	Incidence of Fatalities ^b			Incidence of Injuries ^b		
	Construction	Phase I Operations	Phase II Operations	Construction	Phase I Operations	Phase II Operations
Storage as UF ₆	0.04 – 0.20	0.04	0.02	16 – 72	48 – 53	25 – 29
Storage as U ₃ O ₈	0.20 – 0.23	0.04	0.02	72 – 83	55 – 57	25
Storage as UO ₂	0.09 – 0.10	0.04	0.02	33 – 37	50	22 – 24

^a Impacts are reported as ranges, which result from variations in the employment requirements for the different long-term storage chemical forms and facility types. All construction and operational workers at the storage facilities are included in physical hazard risk calculations.

^b Fatality and injury incidence rates used in the calculations were taken from National Safety Council (1995).

For storage as U₃O₈, the probability of an on-the-job fatality ranges from 0.26 for storage in vaults to 0.29 for storage in buildings — including construction, Phase I, and Phase II of storage. The predicted injury incidence ranges from about 151 to 165 injuries over the lifetime of the facility.

For storage as UO₂, the probability of an on-the-job fatality ranges from 0.14 for storage in vaults to 0.16 for storage in buildings — including construction, Phase I, and Phase II of storage. The predicted injury incidence ranges from about 104 to 111 injuries over the lifetime of the facility.

6.3.3 Air Quality

The methodology used to analyze impacts of the long-term storage options is described in Appendix C of the PEIS and Tschanz (1997a). The storage site was assumed to be centered within the Paducah site boundaries, and pollutant concentrations — CO, HC, NO_x, SO_x, and PM₁₀ — were estimated at the boundaries. Screening modeling of construction emissions was used to estimate hourly pollutant concentrations under very conservative meteorological conditions at the boundary point that would be the shortest distance from the center of the site. The maximum 1-hour concentrations are shown in Table 6.12. These impacts would occur when construction was under way at the corner of the storage site nearest the chosen site boundary. Concentrations from construction at the center of the storage site would be 1.5 to 2 times smaller than the ones listed in

TABLE 6.12 Maximum 1-Hour Pollutant Concentrations at Paducah Site Boundaries as a Result of Long-Term Storage Facility Construction Emissions under Worst-Case Meteorological Conditions

Pollutant	Maximum 1-Hour Concentration (: g/m ³)				
	Aboveground Building Storage			Belowground Vault Storage	
	UF ₆	U ₃ O ₈	UO ₂	U ₃ O ₈	UO ₂
CO	77	94	54	280	140
HC	34	38	21	110	55
NO _x	390	450	250	1,300	670
SO _x	26	30	17	85	44
PM ₁₀ ^a	370	420	240	460	250

^a Fugitive dust emissions from land disturbance have been included with PM₁₀ emissions from construction equipment to estimate total PM₁₀ concentrations.

the table. Among the listed results, the PM₁₀ values might require close consideration in actual construction of any storage facilities similar to the assumed preconceptual ones. Based on the size of the estimated 1-hour concentrations, it is possible that, under particularly unfavorable conditions, concentrations could exceed the 24-hour PM₁₀ standard of 150 : g/m³.

The maximum impacts of CO and NO_x at the site boundaries during operations to place depleted uranium in storage are shown in Table 6.13 for the averaging periods for which standards exist. In all cases, the concentrations due to the storage operations are less than 1% of the standards. Although not shown, the comparisons between SO_x concentrations and the corresponding standards are similar to those for CO.

The emissions from routine monitoring and maintenance following completion of the storage operations in all cases would be less than 25% as large as the operations emissions. Thus, in all cases, the maintenance air quality impacts would be less than 25% of the operations impacts alone.

Some of the estimated criteria pollutant impacts during the operations phase of long-term storage of UF₆ in yards, when both construction and operations would occur simultaneously, are shown in Table 6.14. Construction would be the dominant contributor to most of the impacts, accounting for between 75% of the total for CO to nearly 100% for PM₁₀. The combined impacts of construction and operations would be below the relevant standards, although closer examination of the likely PM₁₀ impacts might be required if this option were to be implemented.

TABLE 6.13 Maximum Pollutant Concentrations at Facility Boundaries from Operations Emissions during Long-Term Storage

Option	CO				NO _x	
	1-Hour Average		8-Hour Average		Annual Average	
	Pollutant Concentration (: g/m ³)	Percent of Standard at Maximum	Pollutant Concentration (: g/m ³)	Percent of Standard at Maximum	Pollutant Concentration (: g/m ³)	Percent of Standard at Maximum
<i>Aboveground Buildings</i>						
Storage as UF ₆	6.8	0.02	1.9	0.02	0.18	0.2
Storage as U ₃ O ₈	7.4	0.02	2.3	0.02	0.24	0.2
Storage as UO ₂	6.9	0.02	1.6	0.02	0.13	0.1
<i>Belowground Vaults</i>						
Storage as U ₃ O ₈	10.1	0.03	3.2	0.03	0.40	0.4
Storage as UO ₂	10.7	0.03	3.1	0.03	0.27	0.3

TABLE 6.14 Maximum Pollutant Concentrations at Facility Boundaries during Operations for the Long-Term Storage of Depleted UF₆ in Yards

Pollutant	Averaging Time	Pollutant Concentration (: g/m ³)		Maximum of Construction and Operations as Percent of Standard
		Construction	Operations	
CO	1 hour	20.6	3.8	0.06
	8 hours	3.1	1.1	0.04
NO _x	Annual	0.61	0.014	0.6
PM ₁₀	24 hours	16	0.012	11
	Annual	1.8	0.0014	4

In the maintenance phase of UF₆ storage in yards, the impacts would be similar to those of operations without construction. The maintenance impacts for CO, NO_x, and PM₁₀ would be 0.71, 0.76, and 0.77, respectively, of those listed for operations in Table 6.14.

Only small quantities of HF would be released from the process stack, averaging 0.06 kg/yr during the operations phase and 0.012 kg/yr during the maintenance phase. The estimated maximum average annual HF concentration is about 2×10^{-6} : g/m³.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue that would be affected by emissions data for the entire area around a proposed long-term storage site. The pollutants most related to ozone formation that would result from the long-term storage of depleted UF₆ are HC and NO_x. In later Phase II studies, when specific technologies and sites would be selected, the potential effects on ozone of these pollutants at a proposed site could be put in perspective by comparing them with the total emissions of HC and NO_x in the surrounding area. Small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region.

6.3.4 Water and Soil

The methodology used to determine water and soil impacts is presented in Appendix C of the PEIS and Tomasko (1997b).

6.3.4.1 Surface Water

To evaluate construction impacts, it was conservatively assumed that construction would be completed in 1 year. Essentially negligible impacts to surface water would be expected for all long-term storage options.

6.3.4.1.1 Buildings

The total land requirements for aboveground storage in buildings would be greatest for storing depleted uranium as U₃O₈ (148 acres [60 ha]) (Table 6.15). Of this area, about 70 acres (29 ha) would be disturbed, and 6 acres (2.4 ha) would be paved. This alteration of soil would impact surface waters by increasing the amount of runoff. At the Paducah site, however, this amount of increased impermeable land would have a negligible impact on nearby rivers (about 0.2% of the site area available for runoff). In addition, there would be no measurable impacts to the existing floodplains.

Water would be needed for constructing the storage buildings. As indicated in Table 6.15, the total quantity of water ranges from about 0.3 million gal/yr (0.6 gpm) for the UO₂ storage option

TABLE 6.15 Summary of Environmental Parameters for Long-Term Storage in Buildings

Option	Requirements		
	Storage as UF ₆	Storage as U ₃ O ₈	Storage as UO ₂
Total land area (acres)	131	148	79
Total disturbed land (acres)	62	72	35
Total paved area (acres)	5	6	4
Excavation (yd ³)	157,000	183,000	81,000
Water (million gal/yr)			
Construction	0.5	0.6	0.3
Phase I	1.2	1.4	1.1
Phase II	1.0	1.0	0.9
Wastewater (million gal/yr)			
Construction	0.05	0.06	0.03
Phase I	1.1	1.2	1.1
Phase II	0.9	0.9	0.8

to about 0.6 million gal/yr (1.1 gpm) for storing depleted uranium as U₃O₈. This water would be obtained from the Ohio River; the impact of this increased use would be negligible (less than $5 \times 10^{-7}\%$ of the average flow).

During construction, wastewater would be discharged to nearby surface waters. About 0.05 million gal/yr (0.1 gpm) of water would be discharged for the U₃O₈ option (see Table 6.15). The primary contaminants of concern would be construction chemicals, organics, and some suspended solids. By following good engineering practices (e.g., stockpiling materials away from surface water drainages, covering construction piles with tarps, and cleaning small chemical spills as soon as they occurred), concentrations in the wastewater would be expected to be very small and well within any regulatory standards. In addition, once in the nearby surface water, dilution would occur in excess of 1 billion:1 for average flows. Because the levels of contamination from construction would be very low, impacts to sediment would also be negligible.

During Phase I, annual water use would range from 1.1 to 1.4 million gal/yr for the three storage forms (UF₆, UO₂, and U₃O₈) (Table 6.15). For a constant rate of use, the maximum withdrawal from the Ohio River would be about 55 gpm. This amount of withdrawal corresponds

to about 0.00005% of the average river flow. The impact of this increase in withdrawal on the flow system (particularly floodplains) would be negligible.

Impacts to surface water quality could also occur during Phase I and II. These impacts would result from releasing water containing chemicals or radionuclides. The maximum wastewater release of 1.2 million gal/yr (2.3 gpm) would occur during Phase I (Table 6.15). This wastewater would contain low concentrations of pollutants that would be within NPDES guidelines. Additional large dilution would occur in the receiving water.

Impacts to surface waters during Phase II would be even less than the impacts produced by Phase I operations because of smaller volumes of raw water used and wastewater released (Table 6.15). Impacts to surface water would, therefore, be negligible.

None of the accident scenarios presented in LLNL (1997) would produce impacts to surface water. Accidents occurring within the concrete-bottomed buildings would be contained and isolated from surface water, and accidents in which the building fails would primarily produce potential impacts via the air pathway.

6.3.4.1.2 Vaults

The total land requirements for vault storage would be roughly similar to the requirements for building storage (Table 6.16). The amount of increased impermeable land would have a negligible impact on the Ohio River. In addition, there would be no measurable impacts to floodplains.

The quantity of water needed for construction would be similar to that for constructing buildings (Table 6.16). The impact would be negligible for any of the storage forms. During construction, wastewater volumes similar to the building option would be discharged to surface waters (U_3O_8 option; see Table 6.16), and the impacts to surface waters would also be negligible.

During Phase I and Phase II operations, annual water use would be about two times greater than for the building option (Table 6.16). The impact of this withdrawal on the flow system (particularly floodplains) would be negligible, as would the impacts to surface water.

None of the accident scenarios presented in LLNL (1997) would produce impacts to surface water. If an accident occurred within the vault it would be contained and isolated from surface water.

TABLE 6.16 Summary of Environmental Parameters for Long-Term Storage in Vaults

Option	Physical Needs	
	Storage as U_3O_8	Storage as UO_2
Total land area (acres)	212	114
Total disturbed area (acres)	86	40
Total paved area (acres)	21	10
Excavation (million yd^3)	1.7	0.75
Water (million gal/yr)		
Phase I	1.1	1.2
Phase II	0.8	0.9
Wastewater (million gal/yr)		
Construction	0.8	0.4
Phase I	1.1	1.0
Phase II	0.9	0.8

6.3.4.1.3 Yards

For long-term storage of depleted uranium as UF_6 in yards, 144 acres (58 ha) of land would be disturbed and 13 acres (5.3 ha) would be paved. This alteration of soil would impact local surface waters by increasing the amount of runoff. The amount of increased runoff, however, would be negligible on a sitewide scale because the land area affected would be about 0.3% of the land area available. In addition there would be no measurable impacts to the existing floodplains.

Water would be needed for constructing the long-term storage yards. Approximately 6.4 million gal/yr of water would be required. This amount of withdrawal would represent less than 0.00005% of average flow in the Ohio River. The impact of this increase in withdrawal on the flow system (particularly floodplains) would be negligible.

During construction of the storage yard, surface water quality could be impacted. The primary contaminants of concern would be chemicals used in construction, organic compounds, and some suspended solids. By following good engineering practices, concentrations in the wastewater would be expected to be very small and less than applicable EPA guidelines. Once the construction water mixed with surface water, dilution would occur. Depending on the volumetric release of water during construction, dilution would be about 1 billion:1.

During normal operations, there would be no emissions that would impact surface water because all cylinders are assumed to be in good condition at the start of the storage option, they would be inspected once every 4 years, and they would be replaced if any handling damage occurred. In addition, no impacts to surface water would result from accidents because no accidents are identified in LLNL (1997) that would produce emissions that would interact directly or indirectly with surface water.

6.3.4.2 Groundwater

The only groundwater impacts for long-term storage in buildings or vaults would occur during construction. Phase I and Phase II operations would produce no impacts because groundwater would not be used as a source for operations and there would be no direct discharges of wastewater to the aquifers. For vault construction, drains would be provided on the upgradient side of the facility to prevent groundwater from entering the facility and mobilizing any spilled contaminants. Accident sequences described in LLNL (1997) would also have no impacts on groundwater because the building, vault, or mine would isolate contaminants and eliminate any direct pathways to the underlying aquifers.

Groundwater quality could be impacted by construction. For example, chemicals stored on the ground could be mobilized by precipitation and infiltrate to the underlying aquifers. By adopting good engineering and construction practices (e.g., covering material to prevent interaction with rain, promptly cleaning any chemical spills, and providing retention basins to catch and hold contaminated runoff), groundwater concentrations would be kept below EPA (1996) guidelines. Overall, impacts from construction would, therefore, be negligible. Phase I and Phase II operations would have no impacts because groundwater would not be used as a source for operations and there would be no direct discharges of wastewater to the aquifers.

The only groundwater impacts for long-term storage in yards would occur during construction. These impacts would primarily be to groundwater quality; impacts to the depth of groundwater, recharge, and flow direction would not be measurable on a sitewide scale because of the limited size of the facility. Impacts could, however, affect quality. For example, chemicals stored on the ground could be mobilized by precipitation and infiltrate to the underlying aquifers. By adopting good engineering and construction practices, impacts to quality would be minimized, and groundwater concentrations would be kept below EPA (1996) guidelines.

As with surface water, there would be no emissions that would impact groundwater during normal operations because all cylinders were assumed to be in good condition at the start of the storage option, they would be inspected once every 4 years, and they would be replaced if any handling damage occurred. In addition, no accident scenarios identified in LLNL (1997) would lead to direct or indirect groundwater contamination.

6.3.4.3 Soil

6.3.4.3.1 Buildings

The only impacts to soil from long-term storage in buildings would occur during construction. The maximum impact would occur for construction of the U_3O_8 building (Table 6.15). Up to 148 acres (60 ha) of land (4.3% of the land area available) would be disturbed, and 183,000 yd³ (140,000 m³) of soil would be excavated. These impacts would include modifications in the local topography, increased permeability and erosion potential in areas where the land surface is plowed, decreased permeability and erosion potential in areas where the soil is compacted by heavy equipment, and decreased soil quality in areas exposed to chemical alteration. On a sitewide scale, the impacts would be moderate; however, the impacts would be temporary. That is, with time the disturbed soil conditions would return to previous conditions everywhere except in paved lots. As discussed in Section 6.3.4.1.1, this area would be about 6 acres (2.4 ha) (0.2% of the total land area available). On a sitewide scale, this impact would be negligible.

By following good engineering practices (e.g., disturbing as little soil as possible, contouring and reseeded disturbed land, scheduling activities to minimize land disturbance, controlling runoff, using tarps to prevent chemical/rainfall interaction, and cleaning any spills as soon as they occur), impacts to soils would be minimized.

6.3.4.3.2 Vaults

The only impacts to soil from long-term storage in vaults would occur during construction. The largest impact to soils would occur for construction of the U_3O_8 vault (Table G.16). Up to 212 acres (86 ha) of land (about 6% of the land area available) would be disturbed, and up to 1.7 million yd³ (1.3 million m³) of soil would be excavated. These impacts would include modifications in the local topography. If the excavated soil were spread evenly over the 212-acre (86-ha) facility, a mound 5 ft (1.5 m) deep would be created. This impact could be mitigated by trucking the soil off-site. Other impacts would include increased permeability and erosion potential in areas where the land surface is plowed or mounded, decreased permeability and erosion potential in areas where the soil is compacted by heavy equipment, and decreased soil quality in areas exposed to chemical alteration. On a sitewide scale, the impacts would be moderate; however, the impacts would, to a large extent, be temporary and readily mitigated. With time the disturbed soil conditions would be returned to existing conditions everywhere except in paved lots. As discussed in Section 6.3.4.1.2, this area would be a maximum of 21 acres (8.5 ha) (0.6% of the total land area available). On a sitewide scale, this impact would be minor. By following good engineering practices, impacts to soils would be kept to a minimum.

6.3.4.3.3 Yards

About 144 acres (58 ha) of land would be disturbed by construction of the long-term storage yard facility (4.2% of the land area available). Of this area, 13 acres (5.3 ha) would be paved (0.4 to 0.8% of the land area available). In addition, about 250,000 yd³ (192,000 m³) of soil would be excavated. Impacts from construction would include modifications in topography, increased permeability and erosion potential in areas where the soil would be broken, decreased permeability and erosion potential in areas where the soil would be compacted by heavy equipment or paving, and decreased soil quality in areas subjected to chemical loading. On a sitewide basis, the impacts would be moderate, but they would be mostly temporary. That is, with time, soil conditions would return to previous conditions everywhere except beneath paved lots, the 20 UF₆ storage pads, and associated buildings. By following good engineering practices, impacts to soils would be kept to a minimum.

There would be no emissions that would impact soils during normal operations because all cylinders would be inspected once every 4 years, and they would be replaced if any handling damage occurred. In addition, there are no identified accident scenarios that would lead to direct or indirect contamination.

6.3.5 Socioeconomics

Calculations for the analysis of socioeconomic impacts were based on detailed cost data developed for trial storage facilities, including the impacts of facility construction, operation and maintenance, emplacement and closure, and surveillance and monitoring activities. Impacts for each facility are presented for the peak year of construction; operations values are annual averages for the emplacement period.

The potential socioeconomic impacts of long-term storage in yards, buildings, and vaults were estimated using the Paducah site as representative. The impacts of long-term storage at the site on regional economic activity were estimated. The methodology for assessing socioeconomic impacts is discussed in Appendix C of the PEIS.

Long-term storage would probably have a small impact on socioeconomic conditions in the ROI surrounding the site described in Section 2.8. This is partly because a major proportion of expenditures associated with procurement for the construction and operation of each technology option would flow outside of the ROI to other locations in the United States, reducing the concentration of local economic effects of the long-term storage facility.

Slight changes in employment and income would occur in the ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required to construct and operate a long-term storage facility, and other local investment associated with construction and operation. In addition to creating new

(direct) jobs at each site, the facility would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at the site. Jobs and income created directly by a long-term storage facility, together with indirect activity in the ROI, would contribute slightly to reduction in unemployment in the ROI surrounding the site. Minimal impacts are expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of constructing and operating long-term storage facilities were assessed with regard to regional economic activity (measured in terms of employment and personal income) and population, housing, and local public revenues and expenditures. Table 6.17 presents the potential range of impacts for long-term storage options.

6.3.5.1 Long-Term Storage as UF₆

During the peak year of construction of a UF₆ long-term storage yard or building, 100 to 200 direct jobs would be created at the site, and 100 to 220 additional jobs would be indirectly created in the ROI surrounding the site (Table 6.17) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, between 200 and 420 jobs would be created. Construction activity would also produce direct and indirect income in the ROI, with total income of \$7 million to \$13 million produced during the peak year. In the first year of operations of the facility, 90 total jobs would be created. Direct and indirect income would also be produced in the ROI surrounding the site, with total income of \$3 to 4 million in the first year. Construction and operation of a UF₆ storage facility would result in an increase in the projected baseline compound annual average growth rate in employment in the site ROI of less than 0.001 percentage point from 2006 through 2039.

Construction of a UF₆ storage facility would be expected to generate direct in-migration of 130 to 280 in the peak year of construction. Additional indirect job in-migration would be expected into the site ROI, bringing the total number of in-migrants to between 200 and 430 in the peak year (Table 6.17). Operation of the facility would be expected to generate direct job in-migration of 40 in the first year. Additional indirect job in-migration into the ROI would also be expected, bringing the total number of in-migrants to 70 in the first year of operations. Construction and operation of a UF₆ storage facility would result in an increase in the projected baseline compound annual average growth rate in the site ROI population of less than 0.1 percentage points from 2006 through 2039.

A UF₆ storage facility would generate a demand for 70 to 160 additional rental housing units during the peak year of construction (Table 6.17), representing an impact of 5 to 8% on the projected number of vacant rental housing units at the site. A demand for 20 to 30 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.5% on the number of vacant owner-occupied housing units at each site.

TABLE 6.17 Potential Socioeconomic Impacts of the Long-Term Storage Options for Yards, Buildings, and Vaults at the Paducah Site

Parameter	Long-Term Storage as UF ₆		Long-Term Storage as UO ₂		Long-Term Storage as U ₃ O ₈	
	Construction ^a	Operations ^b	Construction ^a	Operations ^b	Construction ^a	Operations ^b
Economic activity in the ROI						
Direct jobs	100 – 200	50	120 – 140	70	170 – 210	60
Indirect jobs	100 – 220	40	130	40 – 50	180 – 200	50
Total jobs	200 – 420	90	250 – 270	110 – 120	350 – 410	110
Income (\$ million)						
Direct income	5 – 9	3	5 – 6	3	8 – 9	3 – 4
Total income	7 – 13	3 – 4	8 – 9	4	11 – 13	5 – 7
Population in-migration into the ROI	200 – 430	70	240 – 280	80 – 100	350 – 420	90 – 100
Housing demand						
Number of units in the ROI	70 – 160	20 – 30	90 – 100	30 – 40	130 – 150	30 – 40
Public finances						
Change in ROI fiscal balance (%)	0.1 – 0.3	0.04	0.2	<0.1	0.2 – 0.3	<0.1

^a Impacts are for peak year of construction, either 2007 or 2008. Socioeconomic impacts from construction were assessed for 2007 through 2028.

^b Impacts are the annual averages for the emplacement period (2009–2028). Annual averages for the surveillance and maintenance period (2029–2039) were estimated to be equal to or less than these values.

During the peak year of construction, between 200 and 430 persons would in-migrate into the ROI at each site, leading to an increase of 0.1 to 0.3% over ROI-forecasted baseline revenues and expenditures at the site (Table 6.17). In the first year of operations, 70 in-migrants would be expected, leading to an increase of 0.04% in local revenues and expenditures at the site.

6.3.5.2 Long-Term Storage as UO₂

During the peak year of construction of a UO₂ long-term storage building or vault, 120 to 140 direct jobs would be created at the site and 130 additional jobs indirectly in the ROI surrounding the site (Table 6.17) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, between 250 and 270 jobs would be created. Construction activity would also produce direct and indirect income in the ROI, with total income of \$8 million to \$9 million produced during the peak year. In the first year of operations of the facility, between 110 and 120 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI surrounding the site, with total income of \$4 million in the first year. Construction and operation of a UO₂ storage facility would result in an increase in the projected baseline compound annual average growth rate in employment in the ROI of 0.01 percentage point from 2006 to 2039.

Construction of a UO₂ storage facility would be expected to generate direct in-migration of 160 to 190 in the peak year of construction. Additional indirect job in-migration would be expected into the site ROI, bringing the total number of in-migrants to between 240 and 280 in the peak year (Table 6.17). Operation of the facility would be expected to generate direct job in-migration of between 60 and 70 in the first year. Additional indirect job in-migration into the ROI would also be expected, bringing the total number of in-migrants to between 80 and 100 in the first year of operations. Construction and operation of a UO₂ storage facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.01 percentage point from 2006 to 2039.

A UO₂ storage facility would generate a demand for 90 to 100 additional rental housing units during the peak year of construction, representing an impact of 5.7 to 6.5% on the projected number of vacant rental housing units at the site (Table 6.17). A demand for 30 to 40 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.7% on the number of vacant owner-occupied housing units at the site.

During the peak year of construction, between 240 and 280 persons would in-migrate into the ROI for the site, leading to an increase of 0.2% over ROI-forecasted baseline revenues and expenditures at the site (Table 6.17). In the first year of operations, 80 to 100 in-migrants would be expected, leading to an increase of less than 0.1% in local revenues and expenditures at the site.

6.3.5.3 Long-Term Storage as U_3O_8

During the peak year of construction of a U_3O_8 long-term storage building or vault, 170 to 210 direct jobs would be created at the site and 180 to 200 additional jobs indirectly in the ROI surrounding the site (Table 6.17) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, between 350 and 410 jobs would be created. Construction activity would also produce direct and indirect income in the ROI, with total income of \$11 million to \$13 million produced during the peak year. In the first year of operations of the facility, 110 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI surrounding the site, with total income of \$5 million to \$7 million in the first year. Construction and operation of a U_3O_8 storage facility would result in an increase in the projected baseline compound annual average growth rate in employment in the ROI of less than 0.1 percentage point from 2006 through 2039.

Construction of a U_3O_8 storage facility would be expected to generate direct in-migration of 230 to 290 in the peak year of construction. Additional indirect job in-migration would be expected into the site ROI, bringing the total number of in-migrants to between 350 and 420 in the peak year (Table 6.17). Operation of the facility would be expected to generate direct job in-migration of 60 to 70 in the first year. Additional indirect job in-migration into the ROI would also be expected, bringing the total number of in-migrants to between 90 and 100 in the first year of operations. Construction and operation of a U_3O_8 storage facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.1 percentage point from 2006 through 2039.

A U_3O_8 storage facility would generate a demand for 130 to 150 additional rental housing units during the peak year of construction, corresponding to an impact of 8.2% on the projected number of vacant rental housing units at the site (Table 6.17). A demand for 30 to 40 additional owner-occupied housing units would be expected in the first year of operations, corresponding to an impact of 0.7 to 0.8% on the number of vacant owner-occupied housing units at the site.

During the peak year of construction, between 350 and 420 persons would in-migrate into the ROI at each site, leading to an increase of 0.2 to 0.3% over ROI-forecasted baseline revenues and expenditures at the site (Table 6.17). In the first year of operations, 90 to 100 in-migrants would be expected, leading to an increase of less than 0.1% in local revenues and expenditures at the site.

6.3.6 Ecology

Moderate to large adverse impacts to ecological resources could result from construction of a facility for long-term storage as UF_6 , U_3O_8 , or UO_2 . Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a storage facility would be negligible.

6.3.6.1 Storage as UF₆

Site preparation for the construction of a facility to store UF₆ in buildings would require the disturbance of approximately 131 acres (53 ha), including the permanent replacement of about 62 acres (25 ha) of current land cover with structures and paved areas. Existing vegetation would be destroyed during land-clearing activities. The vegetation communities that would be eliminated by site preparation would depend on the location of the facility. Communities occurring on undeveloped land at the site are relatively common and well represented in the vicinity; however, impacts to high-quality native plant communities might occur if facility construction required disturbance to vegetation communities outside the currently fenced area. Construction of the storage facility would not be expected to threaten the local population of any species. The loss of up to 131 acres (53 ha) of undeveloped land would constitute a large adverse impact to vegetation. Erosion of exposed soil at the construction site could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table 6.18.

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities and competition would increase in these areas, potentially reducing the chances of survival or reproductive capacity of displaced individuals. Some wildlife species would be expected to quickly recolonize replanted areas near the storage facility following completion of construction. The permanent loss of 62 acres (25 ha) to 131 acres (53 ha) of habitat would not be expected to threaten the local population of any wildlife species since similar habitat would be available in the vicinity of the site. However, habitat use in the vicinity of the facility may be reduced for some species due to the construction of a perimeter fence enclosing a 131-acre (53-ha) area. Overall, construction of a facility for UF₆ storage would be considered a moderate to large adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible. Thus, construction derived impacts to aquatic biota would also be expected to be negligible. Wetlands could potentially be filled or drained during construction. In addition, impacts to wetlands due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the storage facility were located immediately adjacent to wetland areas. However, impacts to wetlands would be minimized by maintaining a buffer area around wetlands during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Water Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

Critical habitat has not been designated for any state or federally listed threatened or endangered species at the site. Prior to construction of a storage facility, a survey for state and federally listed threatened, endangered, or candidate species, or species of special concern would be

TABLE 6.18 Impacts to Ecological Resources from Construction of Long-Term Storage Facilities for Depleted Uranium

Option/Resource	Buildings	Vaults	Yards
<i>Storage as UF₆</i>			
Vegetation	Loss of 131 acres Large adverse impact	Not applicable ^a	Loss of 144 acres Large adverse impact
Wildlife	Loss of 62 to 131 acres Moderate to large adverse impact	Not applicable	Loss of 77 to 144 acres Large adverse impact
Aquatic species	Negligible impact	Not applicable	Negligible impact
Wetlands	Potential adverse impact	Not applicable	Potential adverse impact
Protected species	Potential adverse impact	Not applicable	Potential adverse impact
<i>Storage as U₃O₈</i>			
Vegetation	Loss of 148 acres Large adverse impact	Loss of 212 acres Large adverse impact	Not applicable ^a
Wildlife	Loss of 72 to 148 acres Large adverse impact	Loss of 86 to 212 acres Large adverse impact	Not applicable
Aquatic species	Negligible impact	Negligible impact	Not applicable
Wetlands	Potential adverse impact	Potential adverse impact	Not applicable
Protected species	Potential adverse impact	Potential adverse impact	Not applicable
<i>Storage as UO₂</i>			
Vegetation	Loss of 79 acres Moderate adverse impact	Loss of 114 acres Large adverse impact	Not applicable ^a
Wildlife	Loss of 35 to 79 acres Moderate adverse impact	Loss of 40 to 114 acres Large adverse impact	Not applicable
Aquatic species	Negligible impact	Negligible impact	Not applicable
Wetlands	Potential adverse impact	Potential adverse impact	Not applicable
Protected species	Potential adverse impact	Potential adverse impact	Not applicable

^a Long-term storage as UF₆ in vaults and long-term storage as U₃O₈ or UO₂ in yards were not considered.

conducted so that, if possible, impacts to these species could be avoided. Where impacts were unavoidable, appropriate mitigation could be developed.

Small releases of HF would be expected to occur during operation of the building storage facility. The air concentration of HF from facility operations would be less than 2×10^{-6} : g/m³, well below levels injurious to wildlife. Resulting impacts to wildlife would be negligible.

Impacts due to construction of a facility to store UF₆ in yards would be similar to impacts from storage in buildings, although a larger area would be affected. Facility construction would require the disturbance of approximately 144 acres (58 ha), including the permanent replacement of approximately 90 acres (37 ha) with buildings and paved areas. Compared with the building storage facility, a smaller proportion of the yard storage facility would be available for wildlife habitat. Construction of a facility to store UF₆ in yards would constitute a large adverse impact to vegetation and wildlife. Potential impacts associated with facility construction are shown in Table 6.18.

Small releases of HF, UO₂F₂, and U₃O₈ would be expected to occur during operation of the yard storage facility due to transfers of UF₆ from defective cylinders. The maximum annual average air concentration at a storage site boundary from operation of a yard storage facility would be less than 2.8×10^{-6} : g/m³ for HF, 5.3×10^{-7} : g/m³ for UO₂F₂, and 1.8×10^{-9} : g/m³ for U₃O₈. Impacts to wildlife from these emissions are expected to be negligible.

Storage facility accidents could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on such factors as location of the accident, season, and meteorological conditions.

6.3.6.2 Storage as U₃O₈

The construction of a facility to store U₃O₈ in buildings would generally result in the types of impacts associated with UF₆ building storage. Site preparation for the construction of a facility to store U₃O₈ in buildings would require the disturbance of approximately 148 acres (60 ha), including the permanent replacement of approximately 72 acres (29 ha) of current land cover with structures and paved areas. Construction of the storage facility would not be expected to threaten the local population of any species. The loss of up to 148 acres (60 ha) of undeveloped land would constitute a large adverse impact to vegetation. Releases of contaminants are not expected to occur during operation of the storage facility, therefore, impacts to biotic resources due to facility operation would be negligible. Impacts due to facility construction are shown in Table 6.18.

The permanent loss of 72 to 148 acres (29 to 60 ha) of habitat would not be expected to threaten the local population of any wildlife species since similar habitat would be available in the vicinity of the site. However, habitat use in the vicinity of the facility might be reduced for some species due to the construction of a perimeter fence enclosing a 148-acre (60-ha) area. Therefore,

construction of a facility for U_3O_8 storage in buildings would be considered a large adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible. Thus, construction derived impacts to aquatic biota would also be expected to be negligible.

Impacts due to construction of a facility to store U_3O_8 in vaults would be similar to impacts from storage in buildings, although a larger area would be affected. Facility construction would require the disturbance of approximately 212 acres (86 ha), including the permanent replacement of approximately 86 acres (35 ha) with structures and paved areas. A larger proportion of the vault storage facility would be available for wildlife habitat in comparison with the building storage facility. Species diversity and abundance, however, would be expected to be low because of human presence, proximity of buildings, and the relatively poor habitat quality of landscaped areas. Construction of a facility to store U_3O_8 in vaults would constitute a large adverse impact to vegetation and wildlife. The larger size of the facility also would increase the potential for unavoidable direct and indirect impacts to wetlands due to facility location. Impacts due to facility construction are shown in Table 6.18. Releases of contaminants are not expected to occur during operation of the vault storage facility, therefore, impacts to biotic resources due to facility operation would be negligible.

6.3.6.3 Storage as UO_2

The construction of a facility to store UO_2 in buildings would generally result in the types of impacts associated with UF_6 building storage. Site preparation for the construction of a facility to store UO_2 in buildings would require the disturbance of approximately 79 acres (32 ha), including the permanent replacement of approximately 35 acres (14 ha) with structures, including paved areas. Construction of the storage facility would not be expected to threaten the local population of any species. The loss of up to 79 acres (32 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. Impacts due to facility construction are shown in Table 6.18.

The permanent loss of 35 to 79 acres (14 to 32 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the site. However, habitat use in the vicinity of the facility might be reduced for some species due to the construction of a perimeter fence enclosing a 79-acre (32-ha) area. Therefore, construction of a facility for UO_2 storage would be considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible. Thus, construction derived impacts to aquatic biota would also be expected to be negligible.

Impacts due to construction of a facility to store UO_2 in vaults would be similar to impacts from storage in buildings, although a larger area would be affected. Facility construction would require the disturbance of approximately 114 acres (46 ha), including the permanent replacement of approximately 40 acres (16 ha) of current land cover with structures and paved areas. A larger proportion of the vault storage facility would be available for wildlife habitat in comparison with the building storage facility. However, species diversity and population densities would be expected to be low because of human presence, proximity of buildings, and the relatively low habitat quality of landscaped areas. Construction of a facility to store UO_2 in vaults would constitute a large adverse impact to vegetation and wildlife. The larger size of the facility would also increase the potential for unavoidable proximity to wetlands and consequent direct and indirect impacts. Impacts due to facility construction are shown in Table 6.18. Releases of contaminants are not expected to occur during operation of the vault storage facility; therefore, impacts to biotic resources due to facility operation would be negligible.

6.3.7 Waste Management

Impacts on waste management from wastes generated during the long-term storage of depleted UF_6 would be caused by the potential overload of waste treatment and/or disposal capabilities either at a site or on a regional or national scale.

6.3.7.1 Storage of UF_6 in Yards and Buildings

6.3.7.1.1 Yards

Construction of the storage pads and associated support facilities at the Paducah site would generate nonhazardous solid waste and sanitary wastewater. Construction would generate about 3,500 yd^3 (2,700 m^3) of concrete and other solid wastes. Because solid waste disposal facilities can generally be expanded as required, the impact of the construction wastes would be minimal at the Paducah site.

The operations to maintain and store depleted UF_6 cylinders at the Paducah site would consist of inspections, stripping and repainting of the external coating of cylinders, and disposal of scrap metal from old steel cylinders. These operations would generate three primary radioactive waste streams: uranium-contaminated scrap metal (LLW) from replaced cylinders, UO_2F_2 from replaced cylinders (LLW), and solid process residue (LLMW) from cylinder painting. In addition, long-term yard storage operations would generate nonhazardous solid CaF_2 waste and sanitary wastewater. The amount of waste generated would depend upon the time when the activities occurred. For each waste type, the amount of waste generated annually would be larger during Phase I of the operations (see Table 6.19). The waste totals from Phase I were generally used for comparison with the site waste loads.

TABLE 6.19 Estimated Annual Waste Loads from Long-Term Storage of UF₆ in Yards

Waste Type	Waste Load of Depleted UF ₆		
	Annual Load (m ³ /yr)		Total Load (m ³)
	2009–2028	2029–2039	2009–2039
Low-level waste			
Scrap metal	83	44	2,144
UO ₂ F ₂	0.13	0.07	3.37
Low-level mixed waste (inorganic process residue)	8.8	35	561
Nonhazardous waste (CaF ₂)	0.08	0.05	2.15
Sanitary wastewater	6,500	6,700	204,000

Source: DOE (1997).

The 109 yd³/yr (83 m³/yr) of scrap metal LLW and the 0.17 yd³/yr (0.13 m³/yr) of uranyl fluoride generated during Phase I would add 3.8% to site LLW generation (Table 6.19). The maximum amount of LLW generated annually during the continued storage of depleted UF₆ at the Paducah site would represent less than 1% of the projected annual DOE LLW generation. The 46 yd³/yr (35 m³/yr) of LLMW generated during long-term yard storage of depleted UF₆ would add 35% to the LLMW loads at the site, but UF₆ would be less than 1% of the total nationwide LLMW load.

The 0.11 yd³/yr (0.08 m³/yr) of solid nonhazardous waste generated during Phase I would represent less than 1% of the annual waste loads at the site. The 8,700 yd³/yr (6,700 m³/yr) of sanitary wastewater would represent less than 1.5% of the annual wastewater load of the sites.

Overall, the waste input resulting from the long-term yard storage of depleted UF₆ would have negligible impact on radioactive waste management capabilities at the Paducah site. The impact on nonradioactive site waste management would also be negligible. The impacts of waste resulting from the long-term yard storage of depleted UF₆ on national waste management capabilities would be negligible.

6.3.7.1.2 Buildings

The wastes generated during construction of any of the different types of storage facilities would be typical of a large construction project. The only wastes would be construction debris and the sanitary wastes of the labor force. Estimates for the wastewater generated during construction of the different types of UF₆ storage facilities are shown in Table 6.20.

Operation of the UF₆ storage facility would be divided into two phases. Phase I (2009–2028) would involve the receipt, inspection, and repackaging of the depleted uranium containers and relocation of these containers to the storage facility. The wastes generated during this operation would be sanitary wastes of the labor force and the empty containers from the repacking process.

Phase II operations (2029–2039) would involve cylinder inspection, removal, repackaging and replacing of damaged containers. Damaged cylinders were assumed to be LLW. Waste generated during this phase of operations would be sanitary wastes of the labor force and the empty failed cylinders. The conversion of “heels” of UF₆ in damaged cylinders would result in UO₂F₂ waste (LLW) and a CaF₂ waste. The wastes expected from the storage of UF₆ are listed in Table 6.21.

6.3.7.2 Storage of U₃O₈ and UO₂ in Buildings and Vaults

The discussion of waste generation during construction and operations related to the storage of depleted UF₆, as given in Section 6.3.7.1.2, also applies to the storage of U₃O₈ and UO₂. Estimates of wastewater generation during construction of U₃O₈ and UO₂ long-term storage facilities are given

TABLE 6.20 Estimated Total Wastewater Volumes from Construction of Long-Term Storage Facilities for UF₆, U₃O₈, and UO₂

Uranium Compound	Wastewater Volume (million L)		
	Buildings	Vaults	Yards
UF ₆	4.0	NA ^a	24.0
U ₃ O ₈	4.7	6.2	NA
UO ₂	2.1	2.7	NA

^a NA = data not available.

TABLE 6.21 Annual Waste Loads from Long-Term Storage of UF_6 , U_3O_8 , and UO_2 in Buildings and Vaults

Time Period	Low-Level Waste (m ³ /yr)	UO_2F_2 (LLW) (kg/yr)	CaF_2 (Nonhazardous) (kg/yr)	Wastewater (million L/yr)
<i>Storage as UF_6</i>				
Phase I				
Buildings	2.95	140	71	4.2
Vaults	NA ^a	NA	NA	NA
Phase II				
Buildings	0.2	8.8	4.4	3.4
Vaults	NA	NA	NA	NA
<i>Storage as U_3O_8</i>				
Phase I				
Buildings	1.05	NA	NA	4.4
Vaults	1.1	NA	NA	4.3
Phase II				
Buildings	0.05	NA	NA	3.4
Vaults	0.05	NA	NA	3.3
<i>Storage as UO_2</i>				
Phase I				
Buildings	0.75	NA	NA	4.0
Vaults	0.8	NA	NA	3.9
Phase II				
Buildings	0.04	NA	NA	3.1
Vaults	0.04	NA	NA	2.9

^a NA = not applicable.

in Table 6.20. Estimates of waste generation during storage of U_3O_8 and UO_2 are given in Table 6.21. No UO_2F_2 or CaF_2 wastes would be generated in the storing of these waste forms.

6.3.7.3 Summary

Overall, the LLW generated annually during the operation of the different types of storage facilities (yards, buildings, or vaults) would be small (less than 1%) compared with the expected annual LLW generation at the Paducah site. The waste input resulting from the long-term storage of any of the three types of uranium forms would have minimal impact on radioactive waste management capabilities at the site. The impact on nonradioactive waste management would also be minimal. The impacts of waste resulting from the long-term storage of any of the final uranium forms on national waste management capabilities would be negligible.

6.3.8 Resource Requirements

The approach taken for assessment of resource requirements was based on a comparison of required resources with available national and county-level statistics (U.S. Department of Commerce 1997, 1999). More detailed information relating to the methodology is presented in Appendix C of the PEIS.

Resource requirements include all materials necessary to construct and operate the storage facilities. The requirements discussed in this section are for the storage of the three chemical forms of depleted uranium. In general, the amount of resources is directly related to the magnitude of construction, with the least resources required for UF_6 storage in yards. Materials required could include concrete, sand, cement, and steel. In general, none of the construction resources identified are in short supply, and any impacts on the local economies would be small. No strategic and critical materials are projected to be consumed for either construction or operations phases.

Energy resources during construction and operations would include the consumption of diesel fuel and gasoline for construction equipment and transportation vehicles. The anticipated requirements would appear to be small and not impact local or national supplies.

During the operations phase, no chemicals are projected to be required. The amount of natural gas would be relatively small and would be expected to be readily available.

Estimated utilities and materials required for constructing storage facilities for UF_6 , U_3O_8 , and UO_2 are listed in Table 6.22 for the storage options. Estimated utilities and materials required for operating the storage facilities for UF_6 , U_3O_8 , and UO_2 are shown in Table 6.23. The resource requirements are presented separately for Phase I operations, which would be concurrent with the construction period, and for Phase II operations.

TABLE 6.22 Resource Requirements for Constructing UF₆, U₃O₈, and UO₂ Storage Facilities

		Total Consumption	
Utilities/Material	Unit	Yards/ Vaults ^a	Buildings
<i>UF₆ Storage Facility</i>			
Utilities			
Electricity	MWyr	0.40	5.4
Solids			
Concrete	m ³	59,000	69,000
Cement	metric tons	12,000	14,000
Macadam	m ³	3,100	3,100
Steel	metric tons	1,000	29,000
Liquids			
Diesel fuel	million L	0.06	10
Gasoline	thousand L	53	8.6
<i>U₃O₈ Storage Facility</i>			
Utilities			
Electricity	MWyr	6.3	5.4
Solids			
Concrete	m ³	82,000	110,000
Cement	metric tons	16,000	22,000
Macadam	m ³	3,400	12,000
Steel	metric tons	34,000	37,000
Liquids			
Diesel fuel	million L	12	150
Gasoline	thousand L	11	11
<i>UO₂ Storage Facility</i>			
Utilities			
Electricity	MWyr	3.0	2.5
Solids			
Concrete	m ³	37,000	48,000
Cement	metric tons	7,500	9,700
Macadam	m ³	2,200	5,600
Steel	metric tons	16,000	17,000
Liquids			
Diesel fuel	million L	5.3	66
Gasoline	thousand L	3.5	3.7

^a UF₆ options include yards and buildings. U₃O₈ and UO₂ options include vaults and buildings.

Sources: LLNL (1997); Folga (1996d).

TABLE 6.23 Resource Requirements for Operating UF₆, U₃O₈, and UO₂ Storage Facilities

		Annual Requirement			
		Yards		Buildings	
Utilities/Material	Unit	Phase I	Phase II	Phase I	Phase II
<i>UF₆ Storage Facility</i>					
Electricity	MWh	1,700	1,700	1,600	1,600
Natural gas	million scm ^a	0.31	0.31	0.31	0.31
Diesel fuel	thousand L	57	60	52	0.02
Gasoline	thousand L	1.7	2.4	10	8
<i>U₃O₈ Storage Facility</i>					
Electricity	MWh	1,700	1,700	1,700	1,700
Natural gas	million scm	0.35	0.38	0.10	0.10
Diesel fuel	thousand L	65	0.02	120	0.04
Gasoline	thousand L	13	8.5	13	10
<i>UO₂ Storage Facility</i>					
Electricity	MWh	1,200	1,200	1,100	1,100
Natural gas	million scm	0.21	0.21	0.10	0.10
Diesel fuel	thousand L	39	0.01	93	0.04
Gasoline	thousand L	8.0	5.7	8.5	6.3

^a scm = standard cubic meter.

Source: LLNL (1997).

6.3.9 Land Use

Land area requirements for each uranium chemical form and relevant storage option are presented in Table 6.24. These data do not include acreage required for the construction phase for any of the storage options because development of land would be incremental and space required for material excavation storage, equipment staging, and construction material laydown areas would be available on adjacent undeveloped parcels. Consequently, the areal need for construction would not be greater than that for operations.

TABLE 6.24 Land Requirements for the Long-Term Storage Options

Option	Land Requirement ^a (acres)		
	Yards	Buildings	Vaults
Storage as UF ₆	144	131	NA ^b
Storage as U ₃ O ₈	NA	148	212
Storage as UO ₂	NA	79	114

^a There is no distinction between construction and operations because the storage areas would be cleared incrementally on the basis of need. Consequently, the acreage requirements listed here are the total number of acres required to meet the capabilities of the option.

^b NA = not applicable (option does not include this method of storage).

Source: LLNL (1997).

Selection of a storage facility location within the Paducah site that is already dedicated to similar use could result in reduced land use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

6.3.9.1 Storage as UF₆

In general, impacts to land use from the construction and operation of facilities dedicated to storage of depleted uranium in a UF₆ chemical form would be negligible and limited to clearing of required land, potential minor and temporary disruptions to contiguous land parcels, and a slight increase in vehicular traffic.

A storage building option would require 131 acres (53 ha) of land, and the storage yard option would require 144 acres (58 ha). These areas represent about 4% of the Paducah site land. The amount of land required for the storage as UF₆ options could result in potential land disturbance impacts, particularly if the site location featured land that was heavily wooded.

Road and rail access within a storage site, regardless of storage option, would be designed to minimize on-site traffic conflicts. For off-site traffic, potential impacts associated with construction vehicles could be encountered. The maximum labor force required for operation at a long-term storage facility, regardless of the storage option, would not be great enough to generate traffic impacts.

6.3.9.2 Storage as U_3O_8

Storage as U_3O_8 would require the greatest amount of land per option (see Table 6.24) and would result in the greatest amount (1,700,000 yd³ [1,300,000 m³]) of excavated material and rock spoils. Disposal of the excavation material could result in minor land-use impacts that range from temporary disruptions of local traffic to minor land modification at the disposal site. Areal requirements for storage as U_3O_8 would range from 148 to 212 acres (59 to 86 ha). Consequently, the potential for land disturbance impacts would be greater than that expected for storage as either UF_6 or UO_2 .

Road and rail access within a storage site, regardless of storage option, would be designed to minimize on-site traffic conflicts. For off-site traffic, only temporary minor impacts associated with construction vehicles could be encountered. The maximum labor force required for operation, regardless of the storage option, would not be great enough to generate traffic impacts.

6.3.9.3 Storage as UO_2

Storage as UO_2 would require the least amount of land per option (see Table 6.24) and would result in the least amount (750,000 yd³ [575,000 m³]) of excavated material and rock spoils. Disposal of the excavation material could result in land-use impacts, but such impacts are expected to be negligible and of a lesser magnitude than would occur under storage as U_3O_8 or UF_6 . Less land would have to be cleared for storage facilities (between 25 and 40 acres [10 and 16 ha]). Consequently, the potential for land disturbance impacts would be less than that expected for storage as either UF_6 or U_3O_8 . The maximum labor force required for operations would not be great enough to generate off-site traffic impacts.

6.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the storage options considered in this report were implemented include impacts to cultural resources and environmental justice, as well as impacts to the visual environment (e.g., aesthetics), recreational resources and noise levels, and

impacts associated with decontamination and decommissioning of the storage facilities. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- The impacts could not be determined at the programmatic level without considering specific locations for construction within the Paducah site, which are not currently known. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific locations are considered.
- Consideration of these impacts would not contribute to differentiation among the alternatives and therefore would not affect the decisions to be made in the ROD for the PEIS.

6.4 POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH LONG-TERM STORAGE OF THE ENTIRE CYLINDER INVENTORY AT THE PADUCAH SITE

After the draft PEIS was completed, management responsibility for approximately 11,200 additional cylinders of depleted UF₆ was transferred from USEC to DOE by the signing of two MOAs associated with the privatization of USEC (DOE and USEC 1998a,b). To account for uncertainties associated with the number of cylinders that would be transferred from USEC to DOE in the future and to provide a bounding analysis of environmental impacts, the final PEIS evaluated the environmental impacts of managing an additional 15,000 cylinders. These analyses are summarized in Chapter 6 of the PEIS; impacts associated with long-term storage of the entire inventory (including USEC cylinders) at the Paducah site are summarized in Section 6.4.2.

6.4.1 Approach Used to Evaluate the Environmental Impacts of Long-Term Storage for the Entire Cylinder Inventory

To account for the management of USEC-generated cylinders in the long-term storage options, the basic facility designs were assumed to remain the same, but the facilities were assumed to operate over a longer period of time. It was assumed that the period for operations would be extended by about 6 years to accommodate the additional USEC-generated cylinders (i.e., from 20 to 26 years). Under this assumption, annual impacts would generally remain the same as those reported on in Section 6.3, although the total impacts would generally increase by about 30%. Additionally, the land use requirements for the long-term storage options would be increased by about 30% to accommodate the additional inventory.

The assumption that operations at long-term storage facilities would be extended by 6 years did not change the basic analytical time frame used (i.e., 41 years, from 1998 through 2039). As a result of including the USEC cylinders, the time frame for operations (including emplacement of the

entire inventory) at long-term storage facilities was assumed to be from the year 2009 through 2034; monitoring operations at long-term storage facilities were assumed to occur from 2035 through 2039. At a long-term storage facility, surveillance and maintenance requirements would be increased during the years of monitoring, for a total increase of about 30% for the surveillance and maintenance period of 2035 through 2039.

6.4.2 Potential Environmental Impacts from Long-Term Storage of the Entire Cylinder Inventory (DOE- and USEC-Generated Cylinders)

6.4.2.1 Human Health and Safety — Normal Operations

6.4.2.1.1 Workers

In general, the average annual radiation dose to individual workers associated with long-term storage of the additional USEC cylinders would be the same as that for DOE-generated cylinders reported on in Section 6.3.1 (i.e., well within applicable standards) because at long-term storage facilities, the annual worker activities would be the same, but the emplacement activities would be ongoing over a longer period of time. The total doses and numbers of LCFs for involved and noninvolved workers would increase by about 30% (see values in brackets in Table 6.2).

For long-term storage options, the doses to noninvolved workers would remain negligible even with the addition of the USEC cylinders, as discussed in Section 6.3.1.1. Hazardous chemical exposure levels for noninvolved workers would remain negligible as discussed in Section 6.3.1.2.

6.4.2.1.2 General Public

For long-term storage options, the doses to members of the general public would remain negligible even with the addition of the USEC cylinders, as discussed in Section 6.3.1.1. No chemical impacts to the general public would be associated with the increased cylinder inventory.

6.4.2.2 Human Health and Safety — Accident Conditions

6.4.2.2.1 Physical Hazards

The total number of worker fatalities and injuries associated with long-term storage options would increase by about 30% with the addition of the USEC cylinders (see values in brackets in Table 6.2).

6.4.2.2 Accidents Involving Releases of Radiation or Chemicals

For accident consequences, impacts would be the same as those previously discussed for the DOE-generated cylinders (Section 6.3.2), because the types of accidents assessed would involve only a limited amount of material that would be at risk under accident conditions. Although the estimated frequencies of some accidents would increase somewhat in association with the additional USEC-generated cylinders, this increase is not expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used in the PEIS.

6.4.2.3 Air Quality

At a consolidated long-term storage facility, impacts on criteria pollutant emissions from construction and operation would be the same as those for DOE-generated cylinders discussed in Section 6.3.3. The air quality impacts would be the same because, although the size of the long-term storage facility would increase by about 30% as a result of the addition of the USEC-generated cylinders, the annual level of operations (and emissions) would remain unchanged. No emission of uranium compounds was predicted in association with long-term storage options.

6.4.2.4 Water and Soil

Because the duration of construction and operational activities at a long-term storage facility would be increased by 6 years, from 2 to 38 million gal of additional water would be required for construction, and about 7 to 8 million gal of additional water would be required for operations. About 6 to 8 million gal of additional wastewater would be generated. The total amount of water required during construction would range from about 8 to 170 million gal; the total amount of water used during operations would be about 29 to 36 million gal; the total wastewater generated would be about 26 to 34 million gal.

Impacts to surface water and groundwater from long-term storage facilities would partially depend on the actual location within the Paducah site. Because total overall discharges would be extremely small (see Section 6.3.4), no impacts to groundwater quality from the additional USEC-generated cylinders would be expected at a consolidated long-term storage facility.

The addition of USEC-generated cylinders would increase excavation requirements for a long-term storage facility. The additional excavation volumes would be 25–35% for the various options. The total required excavation volumes would range from 323,000 yd³ (250,000 m³) for the storage as UF₆ in yards option to 2.3 million yd³ (1.8 million m³) for the storage as U₃O₈ in vaults option.

6.4.2.5 Socioeconomics

Construction and operation of a long-term storage facility would be extended by 6 years as a result of the addition of the USEC-generated cylinders. The peak-year construction costs would not change. For operations, the emplacement period, originally assumed to extend from the year 2009 through 2028, would be extended through 2034, with the surveillance and maintenance period being reduced to the years 2035 through 2039. The average annual income and number of jobs estimated for the surveillance and maintenance period would increase by about 30% as a result of the addition of the USEC-generated cylinders. To estimate the change in socioeconomic impacts associated with the additional USEC cylinders, 30% of the average annual number of jobs and income during the surveillance and maintenance period for each option were added to the average annual number of jobs and income during the emplacement period from 2009 through 2028 (Allison and Folga 1997). Adding this increased the range for the number of annual direct jobs by 11–15 for the long-term storage options, resulting in a total range of 60–80 direct jobs when both DOE- and USEC-generated cylinders are considered. Correspondingly, annual direct income would increase by about \$1 million, to a total of \$4–5 million.

6.4.2.6 Ecology

At a long-term storage facility, storage as UF_6 would increase land use by 11 to 26 acres (4 to 10 ha), storage as U_3O_8 would increase land use by 14 to 52 acres (6 to 21 ha), and storage as UO_2 would increase land use by 7 to 22 acres (3 to 9 ha). These increases would result in additional habitat loss. The total land required for long-term storage would be about 170 acres (68 ha) for storage as UF_6 , from about 170 to 260 acres (68 to 106 ha) for storage as U_3O_8 , and from about 90 to 135 acres (36 to 54 ha) for storage as UO_2 . These total land requirements would have a moderate to large potential impact on vegetation and wildlife.

6.4.2.7 Waste Management

For the operation and construction of a consolidated long-term storage facility, the addition of the USEC cylinders would generate an additional 26 or 900 yd^3 (20 or 690 m^3) of LLW for storage as UF_6 in buildings or yards, respectively, for the period 2009 through 2039. For UO_2 and U_3O_8 , an additional 7 or 9 yd^3 (5 or 7 m^3) of additional LLW, respectively, would be generated for either the building or vault options. For the entire inventory over the entire period of construction and operations, the total amount of LLW generated from long-term storage options would range from about 26 to 3,700 yd^3 (20 to 2,800 m^3). Impacts to site and national waste management capabilities from of this amount of LLW would be negligible.

6.4.2.8 Resource Requirements

In general, the addition of the USEC cylinders would not change the impact assessment for resource requirements for conversion activities. The construction requirements identified in Section 6.3.8 would remain the same. The annual resource requirements for construction and Phase I operations identified in Tables 6.22 and 6.23 would be extended for an additional 6 years; the Phase II requirements identified in Table 6.23 would increase by about 30%, but the period of Phase II operations would decrease by 6 years. No significant impacts would be expected, because construction and operational requirements would not be resource intensive, and the resources required would not be rare or unique.

6.4.2.9 Land Use

At a long-term storage facility, storage as UF_6 would increase land use by 11 to 26 acres (4 to 10 ha), storage as U_3O_8 would increase land use by 14 to 52 acres (6 to 21 ha), and storage as UO_2 would increase land use by 7 to 22 acres (3 to 9 ha). The total land required for long-term storage would be about 170 acres (68 ha) for storage as UF_6 , from about 170 to 260 acres (68 to 106 ha) for storage as U_3O_8 , and from about 90 to 135 acres (36 to 54 ha) for storage as constituting a moderate to large potential land use impact.

6.4.2.10 Cultural Resources

Impacts to cultural resources from a long-term storage facility at the Paducah site cannot be determined at this time and would depend on the exact location within the site and whether eligible cultural resources existed on or near that location.

6.4.2.11 Environmental Justice

Potential environmental justice impacts to minority and low-income populations from the construction and operation of long-term storage facilities would depend on the locations of these facilities within the Paducah site. Although these specific locations are not known, no disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah site in association with the long-term storage of the entire cylinder inventory (DOE- and USEC-generated cylinders), because impacts from long-term storage activities did not exceed the screening criteria for adverse impacts outlined in Section C.8.2.3 of the depleted UF_6 PEIS.

7 CUMULATIVE IMPACTS

Cumulative impacts are those impacts that result from the incremental impact of an action (in this case, depleted UF₆ management) when added to the impacts of other past, present, and reasonably foreseeable future actions. To conduct the cumulative impacts analysis for the PEIS, DOE examined the impacts associated with depleted UF₆ management activities that would be certain to occur at the Paducah site under all alternatives. The examination included continued cylinder storage for some period for all alternatives and cylinder preparation for shipment for all alternatives except the no action alternative. To these impacts, DOE then added the impacts of other past, present, and reasonably foreseeable future actions in order to assess cumulative impacts. The USEC actions related to enrichment activities were included as a continuation of past DOE actions at the Paducah site. Non-DOE actions were considered when they would occur at the Paducah site or when the nature of their impacts at locations near the site could increase impacts anticipated at the site itself. At the time the PEIS was prepared, locations for conversion and long-term storage activities were not known, so these activities were not included in the cumulative impacts analysis. Since this analysis is taken from the PEIS, these activities are also not included here.

7.1 CUMULATIVE IMPACT ISSUES AND ASSUMPTIONS

The cumulative impact analysis considered the following impact areas for existing operations, depleted UF₆ management options, and other reasonably foreseeable future actions:

- ***Health Risks***
 - Collective radiation dose and cancer risk for the general public over the 41-year period of depleted UF₆ operations,
 - Annual radiation dose for a hypothetical maximally exposed off-site individual,
 - Collective radiation dose and cancer risk for the worker population, and
 - Number of truck or rail shipments of radioactive materials to and from the site and the contributions to the dose to an MEI near the site gate;
- ***Environmental Quality***
 - Potential emissions that affect air quality compared to air quality standards and

- Potential contaminants that affect groundwater quality concentrations compared to drinking water standards or other guideline values;
- ***Resource and Infrastructure Requirements***
 - Land requirements (presented as the percent of suitable land at the site occupied by existing facilities and needed for depleted UF₆ management activities and other future actions),
 - Percent of current water supply (presented as the percent of existing capacity needed for existing operations, depleted UF₆ management activities, and other future actions),
 - Percent of current wastewater treatment capacity (presented as the percent of existing capacity needed for existing operations, depleted UF₆ management activities, and other future actions), and
 - Percent of current power capacity (presented as the percent of existing capacity needed for existing operations, depleted UF₆ management activities, and other future actions).

The health risks to the off-site population are reported as collective exposures and risks for the entire period of conducting a particular operation, while the dose to the MEI is reported as an annual value. Annual exposures are used for the MEI to allow a direct comparison to the DOE maximum dose limit of 100 mrem/yr exposure to an individual of the general public (MEI) from all radiation sources and exposure pathways (DOE Order 5400.5). A cumulative impacts table containing the impact categories and the major elements composing the cumulative impacts is presented for the Paducah site. These elements include the existing conditions at the site, the maximum impacts of depleted UF₆ management activities analyzed in the PEIS, and the impacts of other reasonably foreseeable future actions.

The impact categories addressed as part of the cumulative impact analysis for the site are those associated with depleted UF₆ management that might generate noteworthy environmental effects when aggregated with the environmental consequences of other actions. Some impacts, such as impacts to ecological resources and cultural resources, were not included in the cumulative impact analysis because they are dependent on the specific facility location within the site boundary and location-specific environmental factors. Other impacts, such as impacts of accidents, were not included because it is highly improbable that accidents would occur together.

Cumulative impacts for the Paducah site were evaluated by adding the impacts of depleted UF₆ management options to the impacts of past, present, and reasonably foreseeable future actions at the site and in the region (primarily actions that DOE is considering for other programs). The latter include actions related to production and management of nuclear materials, management of nuclear

fuel, research and development activities, and defense programs. To assess the effects of cumulative impacts, the estimated cumulative impacts calculated for the site were compared to regulatory levels for MEI exposures, air quality standards, and drinking water standards or guidelines for these parameters. If regulatory levels or guidelines would be exceeded, then the impact could be considered significant. LCFs among the public would be considered significant if the cumulative impacts of activities at the site would yield more than 1 LCF over the 41-year period. Because radiological exposure of workers would be maintained at or below regulatory levels, resulting LCFs to those individuals would be those corresponding to acceptable radiation doses. Resources and infrastructure impacts would be considered significant if the land area required, water use, wastewater production, or power demand approached 100% of capacity for the site.

Cumulative impacts also included the consequences of recent and current environmental restoration actions. The impacts of future environmental restoration actions at the site were not included in the cumulative impact analysis because of insufficient characterization of the contamination and because proposals for particular actions are not yet final. Impacts of future environmental restoration activities at the site would be analyzed in later site-specific CERCLA/RCRA program documents.

Past impacts included in the cumulative impact analysis consist of past construction, development, and environmental restoration activities that contributed to existing conditions at the site and any past activities that may have resulted in current groundwater contamination at the site; these are presented as impacts of existing operations.

No assumptions are made regarding future baseline conditions at the site that could potentially reduce impacts, such as cessation of certain ongoing operations that would reduce current levels of radioactive releases. A number of other simplifying assumptions were made to estimate cumulative impacts regarding timing, site location, and consistency of analytical methods. Other existing or planned actions at the site were assumed to occur during the period of depleted UF₆ management operations. These other actions were assumed to be collocated with depleted UF₆ management facilities to the extent that they affect the same off-site population and MEI. These assumptions result in conservative analyses that overestimate actual cumulative impacts.

Some or most of the depleted UF₆ cylinder management activities currently occurring at the site (and considered under existing operations) would persist during continued storage and are included in the impacts of continued storage. When estimating cumulative impacts over the 41-year assessment period, no adjustment was made for this overlap. This adds to the conservatism in the calculated cumulative collective population impacts for both the workers and members of the general public at the site.

The above simplifying assumptions could result in some differences in the estimated cumulative impacts between this report and other site-specific documents. In addition, these simplifying assumptions and other assumptions used in performing calculations can result in some uncertainty regarding projected cumulative impacts. This cumulative impact analysis should be used

only as a starting point for analyzing site-specific cylinder management program activities at the Paducah site; any future site-specific NEPA analysis would supersede this cumulative analysis.

7.2 IMPACTS OF CONTINUED CYLINDER STORAGE AND PREPARATION

This analysis focuses on potential cumulative impacts at the site from continued storage and cylinder preparation. For purposes of analysis, the maximum impacts estimated at the site for continued cylinder storage and cylinder preparation activities from any of the PEIS alternatives were used to provide an upper estimate of potential cumulative impacts.

Actions planned at the Paducah site include the continuation of uranium enrichment operations, waste management activities (including the Vortec vitrification system [DOE 1998]), environmental restoration activities, and the depleted UF₆ management activities addressed in the PEIS. Actions occurring near the Paducah site that could contribute to the existing or future impacts on the site (because of their diffuse nature) include continued operation of the Tennessee Valley Authority's Shawnee power plant; the Joppa, Illinois, power plant (see DOE 1998); and the Allied Signal uranium conversion plant in Metropolis, Illinois (NRC 1995). Table 7.1 identifies the projected cumulative impacts that could result from depleted UF₆ management activities and current activities at the Paducah site. As identified in the table, the maximum annual radioactive releases that would result from depleted UF₆ management would result in an increase in the dose to the off-site population. However, cumulative radioactive releases at the Paducah site would still be considerably below the maximum DOE dose limit of 100 mrem/yr to the off-site MEI.

The depleted UF₆ management options would be unlikely to result in additional land disturbance at Paducah because all activities are expected to occur on currently developed land. On-site infrastructure demands for water, wastewater treatment, and power would increase by at most very small amounts due to the depleted UF₆ management activities. Cumulative requirements would remain well within existing capacities.

The Paducah site is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. During construction activities at the site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM₁₀) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

Data from 1996 annual groundwater monitoring showed 18 pollutants exceeding primary drinking water regulation levels in groundwater at the Paducah site: antimony, chromium, lead, nickel, nitrate, thallium, uranium, benzene, 1,2-dichloroethane, cis-1,2-dichloroethene, 1,1-dichloroethene, ethyl benzene, tetrachloroethene, trichloroethylene, vinyl chloride, radon-222,

TABLE 7.1 Cumulative Impacts of Depleted UF₆ Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Paducah Site, 1999 through 2039

Impact Category	Impacts of Existing Operations ^a	Maximum Impacts of Depleted UF ₆ Management Activities		Impacts of Other Reasonably Foreseeable Future Actions ^c	Cumulative Impacts ^d
		Continued Storage ^b	Cylinder Preparation		
Off-site population					
Collective dose, 41 years (person-rem)	4.8	0.34	0.0030	24.6	29.7
Number of LCFs ^e	0.002	0.0002	1.5×10^{-6}	1.2×10^{-2}	0.02
Annual dose to off-site MEI ^f (mrem)	3.03	0.10	2.0×10^{-5}	1.5	4.6
Worker population					
Collective dose, 41 years (person-rem)	213	900	1,000	4.1	2,117
Number of LCFs ^g	0.09	0.37	0.40	0.0016	0.85
Transportation ^h					
Number of truck shipments, 41 years	40,836	—	28,513	6,330	75,679
Number of rail shipments, 41 years	0	—	7,129	2,410	9,539
Annual dose to MEI from truck (mrem)	3.98	—	0.0077	0.010	4.0
Annual dose to MEI from rail (mrem)	0.0	—	0.0053	0.0041	0.0094
Resources and infrastructure					
Land area (% of site)	21.9	0.0	0.6	0.53	23.0
Water use (% capacity)	50.0	0.09	0.11	0.02	50.2
Wastewater production (% capacity)	22.9	0.0	0.0	0.13	23.0
Power demand (% capacity)	51.5	0.0	0.05	0.03	51.5
Air quality ⁱ	None	PM ₁₀	None	None	PM ₁₀
Groundwater quality ^j	19 parameters ^k	Uranium-238	None	None	19 parameters ^l

^a Includes impacts of current UF₆ generation and management activities; waste management activities; conversion of uranium ore into UF₆ at the AlliedSignal, Inc., plant in Metropolis, Illinois (NRC 1995); electrical power generation at the Tennessee Valley Authority's Shawnee power plant and at the Joppa Electric Energy, Inc., power plant (DOE 1998); and environmental restoration activities that have proceeded to a point where their consequences can be defined: Waste Area Groupings 1 and 7 (Solid Waste Management Units C-611, C-746-K, C-740), Grouping 6 (C-400, C-403, and C-400 to C-404 underground transfer line), Grouping 15 (24—C-750, 97—C-601, 139—C-746-A1, 140—C-746-A2, 72—C-200-A, 73—C-710-B), Grouping 17 (36 different concrete rubble piles), Grouping 22 (C-404, C-747-A, C-749), and Grouping 23 (C-340, C-540-A, C-541-A, C-611, C-728, C-747-C) (LMES 1997c).

^b The greater of either (1) impacts from 41 years of continued storage under the no action alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

^c Includes impacts related to the preferred alternative for waste management at the Paducah site (DOE 1997); continuation of conversion of uranium ore into UF₆ at the AlliedSignal, Inc., plant at Metropolis, Illinois (NRC 1995); and treatment of mixed wastes through the Vortec vitrification system (DOE 1998). They also consider air quality impacts from the Tennessee Valley Authority's Shawnee power plant and from the Joppa Electric Energy, Inc., power plant (DOE 1998).

^d Cumulative impacts equal the sum of the impacts of existing operations, depleted UF₆ management options, and other reasonably foreseeable future actions.

^e Assumes 0.0005 LCF/person-rem.

^f Based on LMES (1996), which contains releases for the year 1994. Cumulative impacts assume all facilities operate simultaneously and are located at the same point.

^g Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

^h The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

ⁱ Impacts indicate which emissions would result in nonattainment. PM₁₀ = particulate matter less than or equal to 10 : m in diameter.

^j Impacts of depleted UF₆ management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected in the future.

^k Antimony, benzene, cis-1,2-dichloroethene, chromium, 1,2-dichloroethane, 1,1-dichloroethene, ethyl benzene, fluoride, lead, nickel, nitrate, radium-226, radon-222, technetium-99, tetrachloroethene, thallium, trichloroethylene, uranium, and vinyl chloride.

^l Only 19 parameters are shown rather than 20 because uranium is included in more than one column (i.e., it is in existing operations as well as continued storage).

Sources: LMES (1996, 1997c); DOE (1997, 1998); NRC (1995).

radium-226, and technetium-99 (LMES 1997c). Fluoride has also exceeded its primary drinking water regulation level of 4 mg/L in two on-site wells (LMES 1996).

During continued storage of depleted UF₆, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 6 : g/L, considerably below the 20 : g/L guideline level used for comparison (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinder breaches occurring at Paducah before the year 2020 could result in groundwater concentrations of uranium exceeding 20 : g/L in the future.

8 PARAMETRIC ANALYSIS: ENVIRONMENTAL IMPACTS OF CONVERSION AND LONG-TERM STORAGE OPTIONS FOR PROCESSING LESS THAN THE TOTAL DEPLETED UF₆ INVENTORY AT THE PADUCAH SITE

The environmental impacts presented in the PEIS were based on the assumption that all facilities would be designed to either convert, store, manufacture and use, or dispose of all of the depleted UF₆ in the DOE inventory. This approach provided a conservative estimate of the impacts that could result from each of the alternatives considered. Detailed discussions of the estimated environmental impacts from processing the entire depleted UF₆ inventory are presented for cylinder preparation, conversion, long-term storage, manufacture and use, disposal, and transportation options in Appendices E through J of the PEIS, respectively. The results of these evaluations are referred to as “100%” cases because they are based on the assumption that all of the depleted UF₆ would be processed (i.e., converted, stored, manufactured and used, disposed of, or transported).

In contrast to the 100% cases, the parametric analysis cases consider the environmental impacts of each option category on the basis of the assumption that the conversion and long-term storage facilities were designed to process or accommodate only a fraction of the depleted UF₆ inventory. The intent of the parametric analysis was to show how the environmental impacts calculated for the 100% cases would be affected by reductions in facility size and throughput. “Throughput” is a general term that refers to the amount of material handled or processed by a facility in a year. Sections 8.2 and 8.3 present the environmental impacts for the conversion and long-term storage options for facilities designed to process between 25% and 100% of the depleted UF₆ inventory at the Paducah site. In the PEIS, only these management activities were analyzed using data for the Paducah site, so these are the available results presented in this section.

For assessment purposes, the parametric analysis assumed that all facilities would be designed to operate over a 20-year time period (i.e., the period required to process the DOE-generated cylinders, similar to the 100% cases presented in Appendices E through J of the PEIS). Thus, it was assumed that the processing of only a fraction of the DOE depleted UF₆ inventory would be accomplished by building and operating smaller facilities than those required for the 100% cases. In practice, it would be possible to process a fraction of the inventory by operating facilities designed to process 100% of the inventory over 20 years for a reduced time period, such as 10 years, or by operating the facility at a reduced level. In addition, changes in operating schedule could be used to accommodate small changes in the DOE inventory. For example, a 10% increase in the total DOE inventory could be accommodated by operating a full-scale facility for 22 years instead of 20.

For a given option, the environmental impacts resulting from the parametric analysis cases would tend to be less than or equal to those presented for the 100% cases. Thus, if the impacts were negligible for the 100% case, the impacts for the parametric cases would also be negligible. For most areas considered — such as human health and safety during normal operations, water, ecology, resource requirements, waste management, land use, and socioeconomics — the impacts would

decrease as the facility size or throughput decreased. However, the reduction in impacts would not always be proportional to the reduction in throughput. For example, a facility designed to process 500 cylinders per year would generally have smaller impacts than a facility designed to process 1,000 cylinders per year, although the impacts would not necessarily be half of those of the larger facility. For accidents producing the greatest consequences, impacts would tend to be the same for the parametric analysis cases and the 100% case, primarily because these types of accidents would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput.

The following sections summarize the approach and results of the parametric analysis. Section 8.1 presents a short summary of the assessment approach. The results are presented for the conversion options in Section 8.2 and for long-term storage options in Section 8.3.

The discussion in this section does not include details of the assessment methodologies or definitions of the options considered in the PEIS. A detailed description of methodologies is presented in Appendix C of the PEIS, and definitions and descriptions of the option categories are provided in Sections 5 and 6 of this document.

8.1 PARAMETRIC ANALYSIS ASSESSMENT APPROACH

Two parametric cases were analyzed for the conversion option and the long-term storage as oxide option: (1) facilities designed to process or accommodate 50% of the depleted UF₆ inventory and (2) facilities designed to process or accommodate 25% of the inventory. To simplify the analysis, the parametric cases were analyzed in detail for a subset of options within each option category, as summarized in Table 8.1. A subset of options was selected because the relationships among the options within each category could be determined from the detailed analyses conducted for the 100% cases. Therefore, the results for the options analyzed in detail were used to estimate the impacts for all options within each category by comparison with the 100% cases.

The basic assessment approach, areas of impact, and methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases. The environmental impacts for the 100% cases were evaluated using information provided in the engineering analysis report (LLNL 1997), including descriptions of facility layouts; resource requirements; estimates of effluents, wastes, and emissions; and descriptions of potential accident scenarios. To support the parametric assessment, similar design information was used for facilities sized to process or accommodate 25% and 50% of the depleted UF₆ inventory (LLNL 1997).

The results of the parametric analysis are presented, where appropriate, as curves that show the environmental impacts as a function of facility throughput. The curves were constructed using the results for the 25%, 50%, and 100% cases. These curves can be used to estimate the environmental impacts for throughputs ranging between 25% and 100% of the depleted UF₆ inventory. In

TABLE 8.1 Specific Options and Parametric Cases Analyzed in Detail for the Paducah Site

Option Category/ Options Analyzed in Detail	Parametric Cases Analyzed for Each Option
Conversion	Conversion to U_3O_8 , UO_2 , and metal: 100% case: Conversion of 100% of the inventory over 20 years 50% case: Conversion of 50% of the inventory over 20 years 25% case: Conversion of 25% of the inventory over 20 years
Long-term storage	
Storage as UF_6 in buildings	Storage as UF_6 : 100% case: Storage of 46,422 cylinders 50% case: Storage of 23,211 cylinders 25% case: Storage of 11,606 cylinders
Storage as UO_2 in buildings	Storage as UO_2 : 100% case: Storage of 420,000 drums 50% case: Storage of 210,000 drums 25% case: Storage of 105,000 drums

addition, the curves can also be used to provide rough estimates of the impacts for throughputs slightly below 25% and slightly above 100%. In cases where the impacts for the 100% case were negligible, the parametric analysis was conducted to confirm that the impacts were also negligible, and only a brief discussion is provided. (The terms used in the PEIS to describe impacts, such as “negligible,” are defined in Chapter 4, Table 4.2, of the PEIS.)

8.2 CONVERSION OPTIONS

The parametric analysis of the conversion options considered the environmental impacts of converting 25% and 50% of the depleted UF_6 inventory to U_3O_8 , UO_2 , or uranium metal over a 20-year period. The assessment considered the environmental impacts that would occur during (1) construction of a conversion facility, (2) routine conversion facility operations, and (3) potential conversion facility accidents. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases, the results of which are discussed in Section 5. The supporting data for the 25% and 50% parametric conversion cases are provided in the engineering analysis report (LLNL 1997).

In general, the impacts for the 100% cases are presented in Section 5 as ranges, resulting from differences in technologies within each option. For the purposes of the parametric analysis in

the PEIS, one technology from each option was considered and evaluated in detail for one of the three representative sites (i.e., Paducah, Portsmouth or K-25). A single technology and a single representative site were evaluated for each option to simplify the parametric analysis. This simplification was possible because all technologies were evaluated at all representative sites for the 100% base case. The specific technologies considered were defluorination with anhydrous HF production for conversion to U_3O_8 ; dry defluorination with anhydrous HF production for conversion to UO_2 ; and continuous metallothermal reduction for conversion to uranium metal. The resulting relationships between the technologies and sites that were identified for the 100% case were used to infer ranges of impacts for the parametric cases examined in detail. Therefore, although not all PEIS parametric analyses were conducted specifically for the Paducah site, the impacts could generally be interpolated to estimate impacts for Paducah.

8.2.1 Human Health — Normal Operations

8.2.1.1 Radiological Impacts

The estimated radiological impacts — radiation doses and latent cancer fatalities (LCFs) — from the normal operation of a full-scale (100%) facility for converting depleted UF_6 to U_3O_8 are described in Section 5.3.1.1. Similar impacts were calculated for the 50% and 25% conversion facilities for the parametric analysis. The radiological impacts estimated for the 100%, 50%, and 25% case are shown in Figures 8.1 through 8.6 as the radiation doses for the six receptor scenarios considered in the PEIS:

- Members of the general public
 - Annual collective dose
 - Annual dose to the MEI
- Noninvolved workers
 - Annual collective dose
 - Annual dose to the MEI
- Involved workers
 - Annual collective dose
 - Annual average individual dose

The ranges of impacts resulting from technology differences for each option are represented by dashed lines in the figures. The results for the technology selected for detailed analysis are shown in the figures as solid points, with a curve drawn between the points to indicate how the impacts vary as a function of the percent of depleted UF_6 processed. The upper and lower bounds for impacts for the 25% and 50% cases were estimated on the basis of the range determined for the 100% case. The

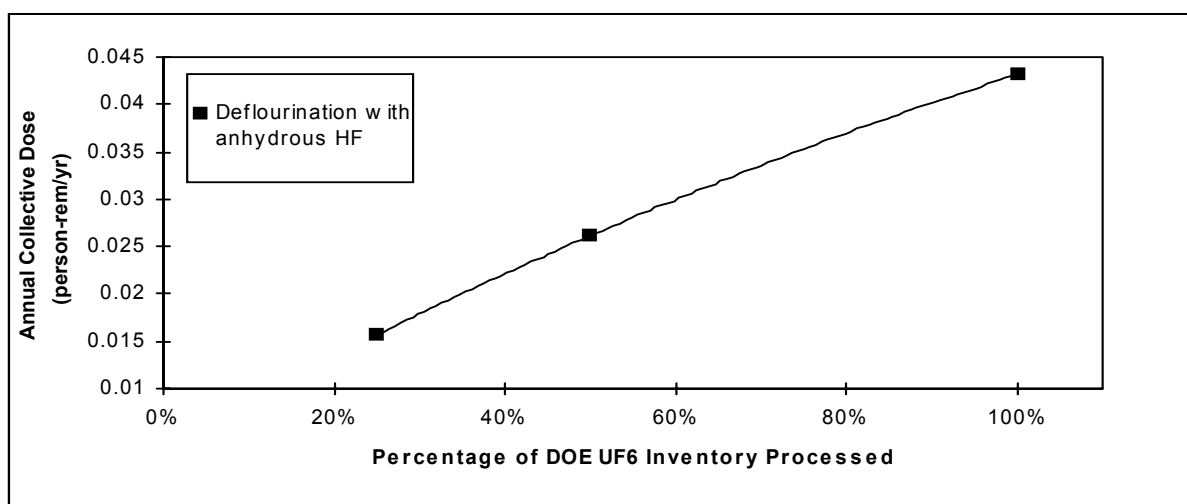


FIGURE 8.1 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to U_3O_8 (No range is presented because the estimated collective doses were almost identical between conversion technologies.)

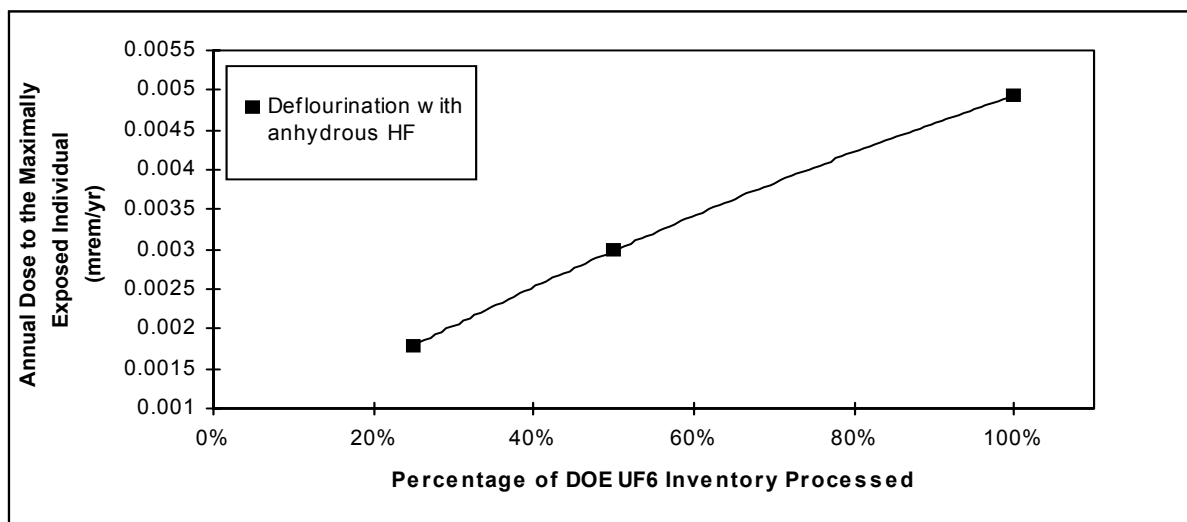


FIGURE 8.2 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to U_3O_8 (No range is presented because the estimated MEI doses were almost identical between conversion technologies.)

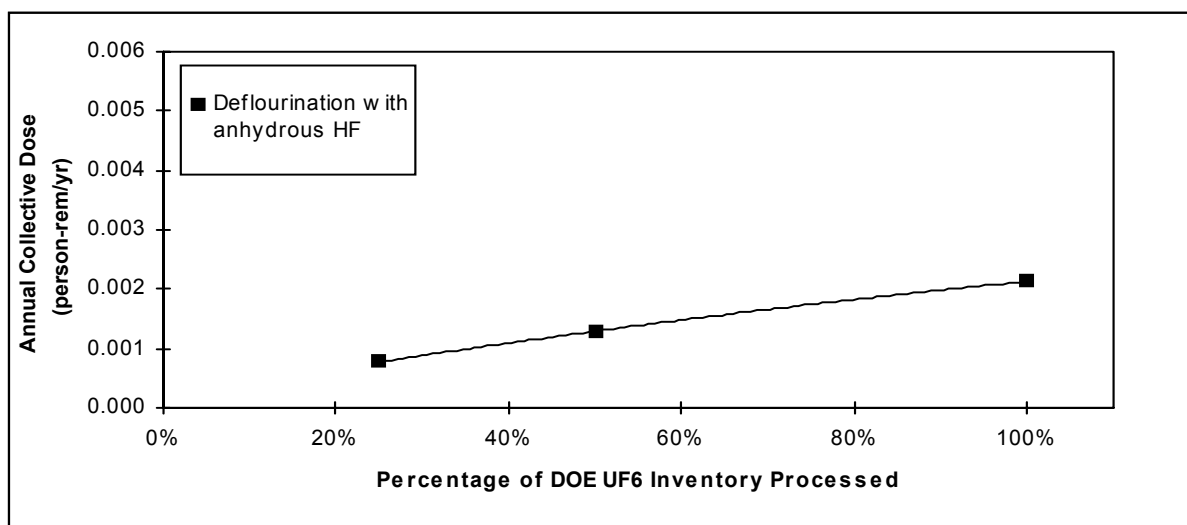


FIGURE 8.3 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF₆ to U₃O₈ (No range is presented because the estimated collective doses were almost identical between conversion technologies.)

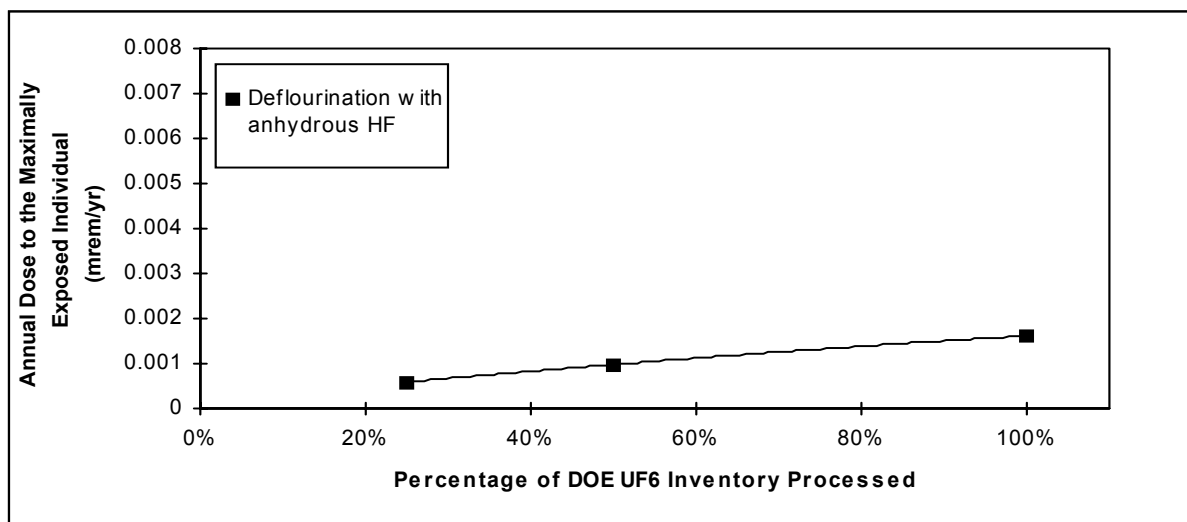


FIGURE 8.4 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF₆ to U₃O₈ (No range is presented because the estimated collective doses were almost identical between conversion technologies.)

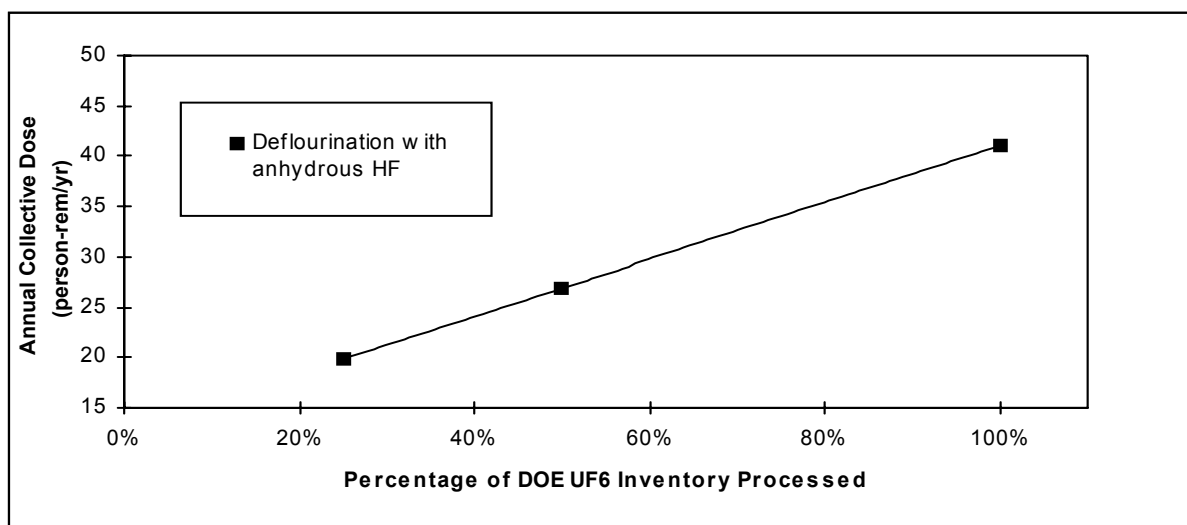


FIGURE 8.5 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to U_3O_8 (No range is presented because the estimated collective doses to involved workers were almost identical between conversion technologies.)

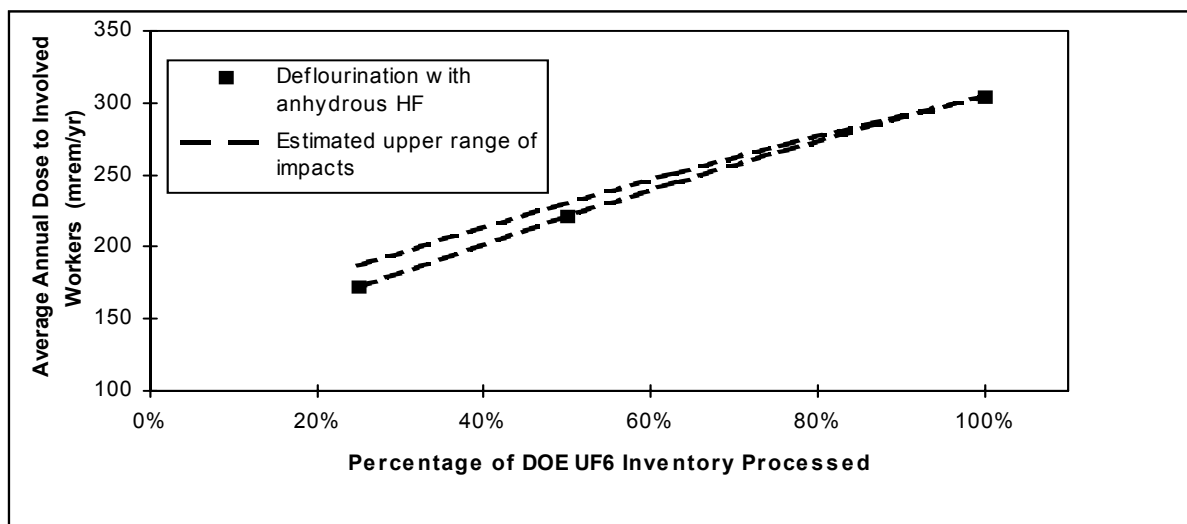


FIGURE 8.6 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in conversion technologies.)

area enclosed by the lines in each figure indicates the range of impacts expected for throughputs between 25% and 100%, taking into account technology differences.

The results of the parametric analysis for conversion to U_3O_8 (as shown in Figures 8.1 through 8.6) indicate that the radiological impacts would scale relatively linearly with the quantity of depleted UF_6 processed annually. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The radiation doses to the general public would be greater than those to noninvolved workers because of longer exposure times and, for the collective dose, larger population size. The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0005 LCF/person-rem for members of the public and 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Section 5.

For conversion to UO_2 , the estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures 8.7 through 8.12 for each of the six receptor scenarios considered in the PEIS. The results are presented in a manner similar to the results discussed previously for conversion to U_3O_8 . The general relationship between radiological impacts and throughput for conversion to UO_2 is similar to that for conversion to U_3O_8 ; that is, the radiological impacts would decrease with decreasing throughput. The estimated radiological impacts (doses and LCFs) from normal operation of a full-scale (100%) facility for converting depleted UF_6 to UO_2 are described in Section 5.3.1.1.

For conversion to metal, the estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures 8.13 through 8.18 for each of the six receptor scenarios considered in the PEIS. Similar to conversion to U_3O_8 and UO_2 , the radiological impacts from conversion to metal would decrease with decreasing throughput. The estimated radiological impacts (doses and LCFs) from the normal operation of a full-scale (100%) facility for converting depleted UF_6 to uranium metal are described in Section 5.3.1.1.

The estimated radiological impacts from operation of the cylinder treatment facility are less than the impacts from the operations of the conversion facilities. Low-level exposures would be expected for involved workers and negligible exposures for noninvolved workers and the general public. The estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures 8.19 through 8.24 for each of the six receptor scenarios considered in the PEIS.

Detailed numerical results for each of the parametric analyses can be found in the tables and attached disks of Cheng et al. (1997). For radiation exposure of the involved workers, the results are presented in Table 5.1 of Cheng et al. (1997) and on disk 3 under the file name conv-tm.xls. For the noninvolved workers and the general public, potential impacts resulting from airborne emission of uranium can be found on disk 1 under the file name airimpct.xls.

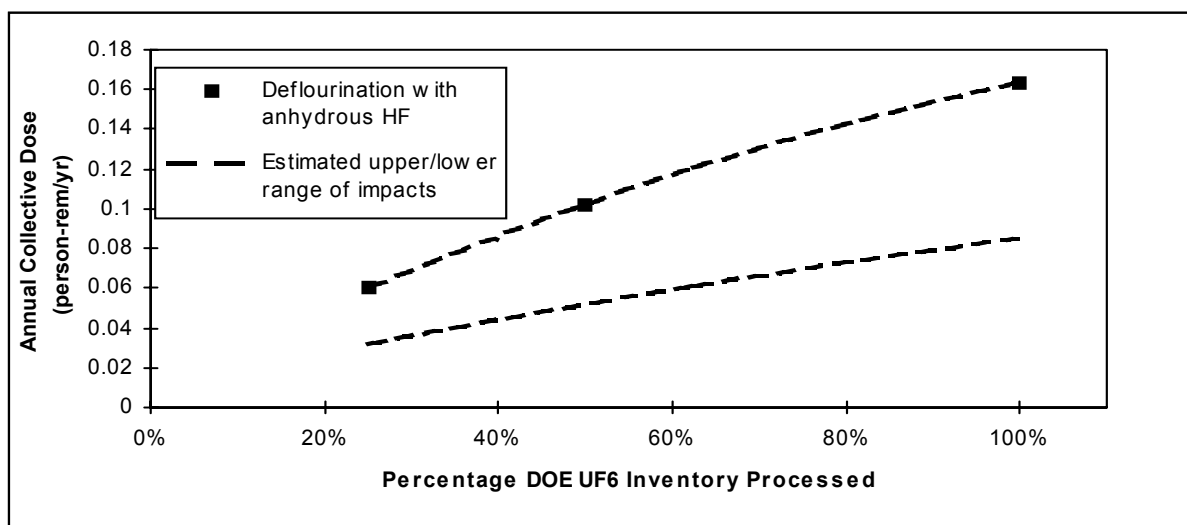


FIGURE 8.7 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF₆ to UO₂ (The upper and lower ranges reflect differences in conversion technologies.)

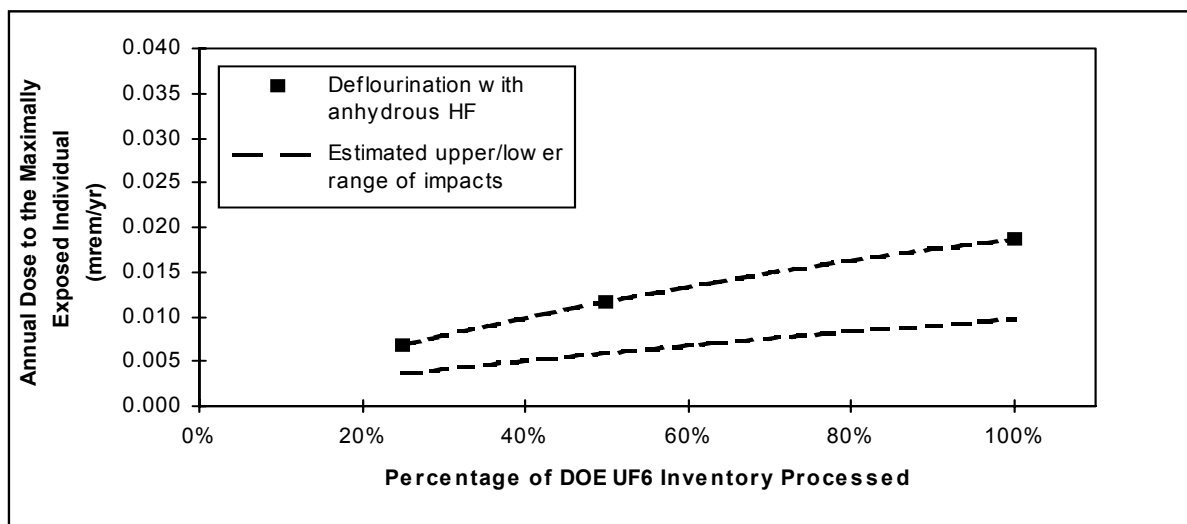


FIGURE 8.8 Estimated Annual Dose to the General Public MEI from the Conversion of UF₆ to UO₂ (The upper and lower ranges reflect differences in conversion technologies.)

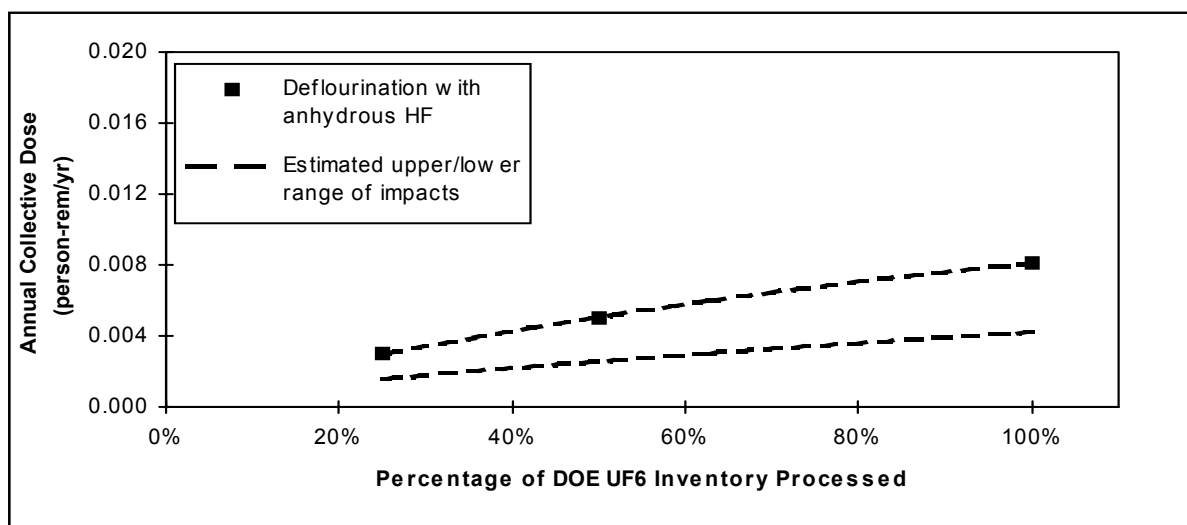


FIGURE 8.9 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

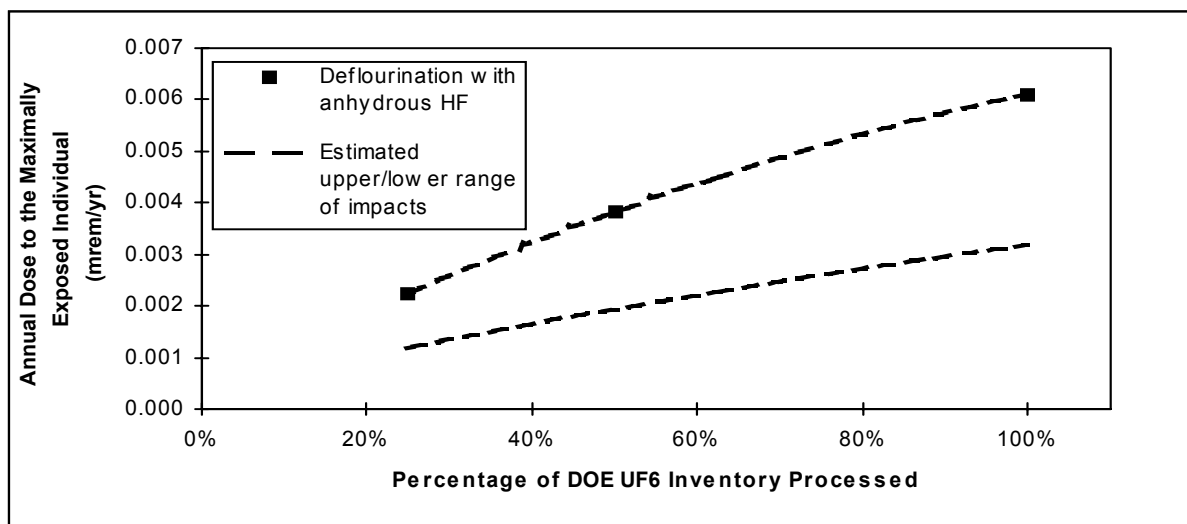


FIGURE 8.10 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

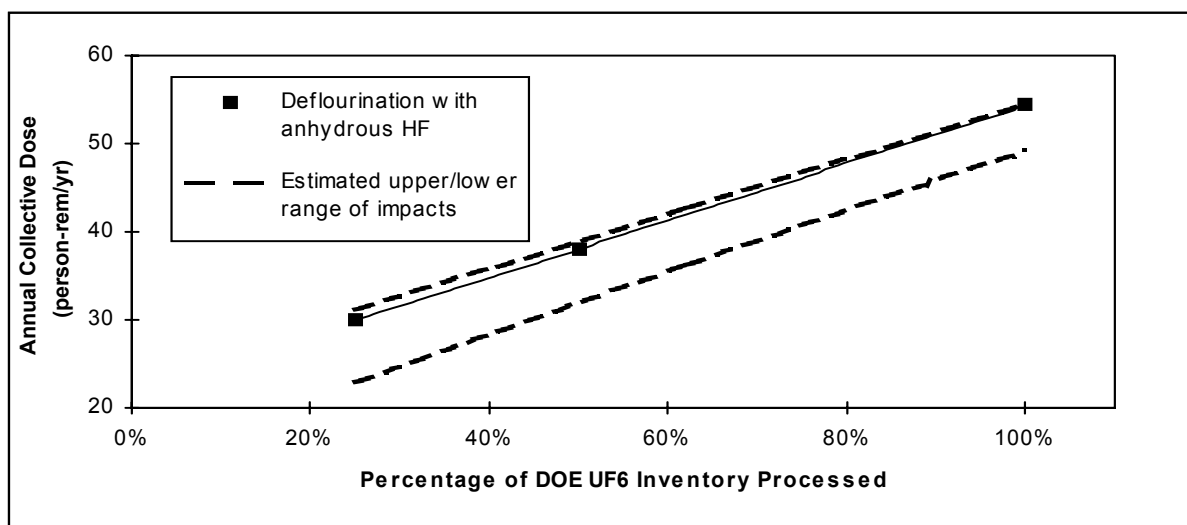


FIGURE 8.11 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

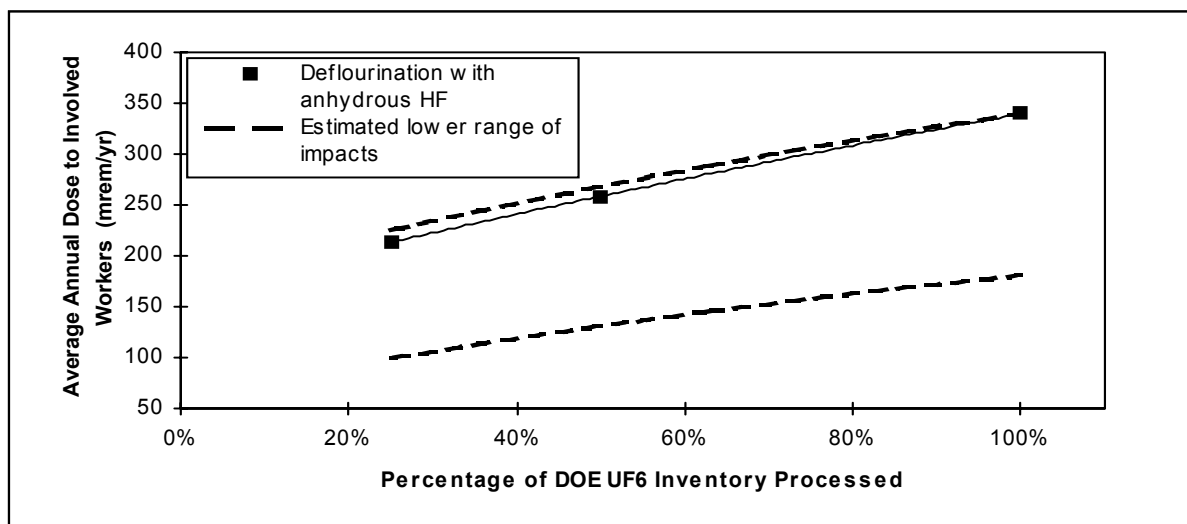


FIGURE 8.12 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

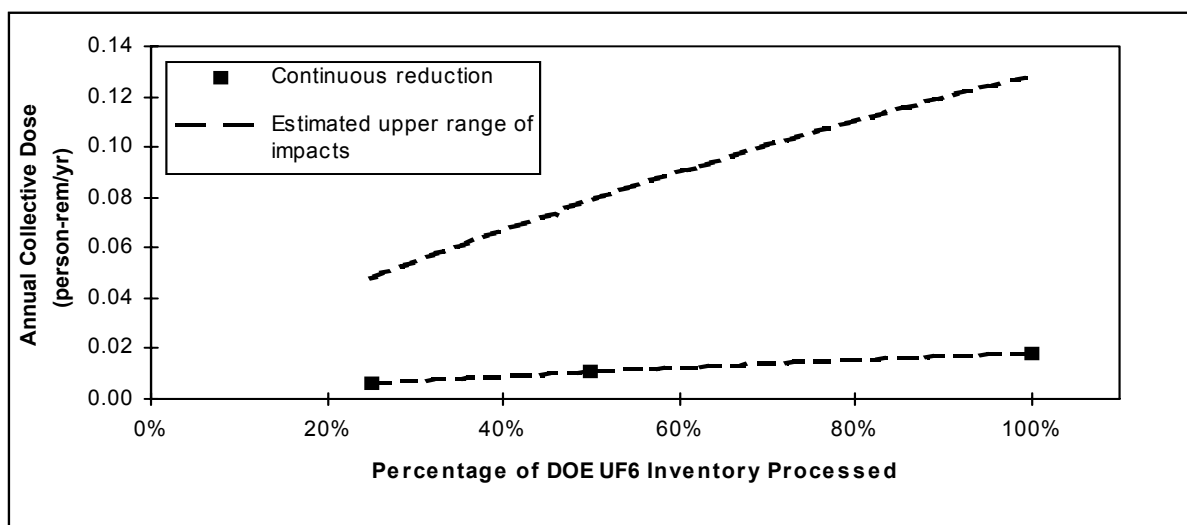


FIGURE 8.13 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

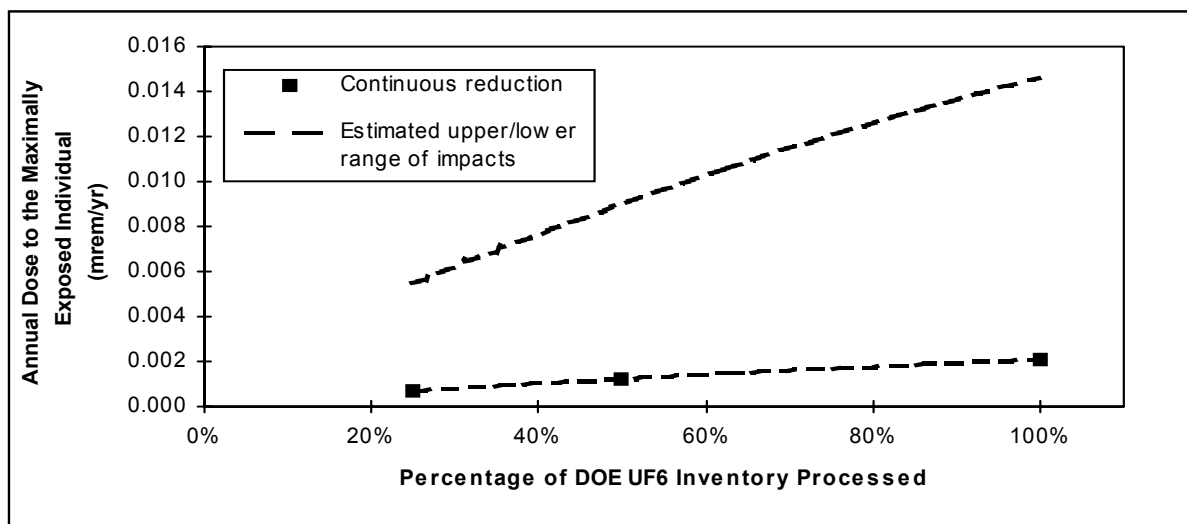


FIGURE 8.14 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

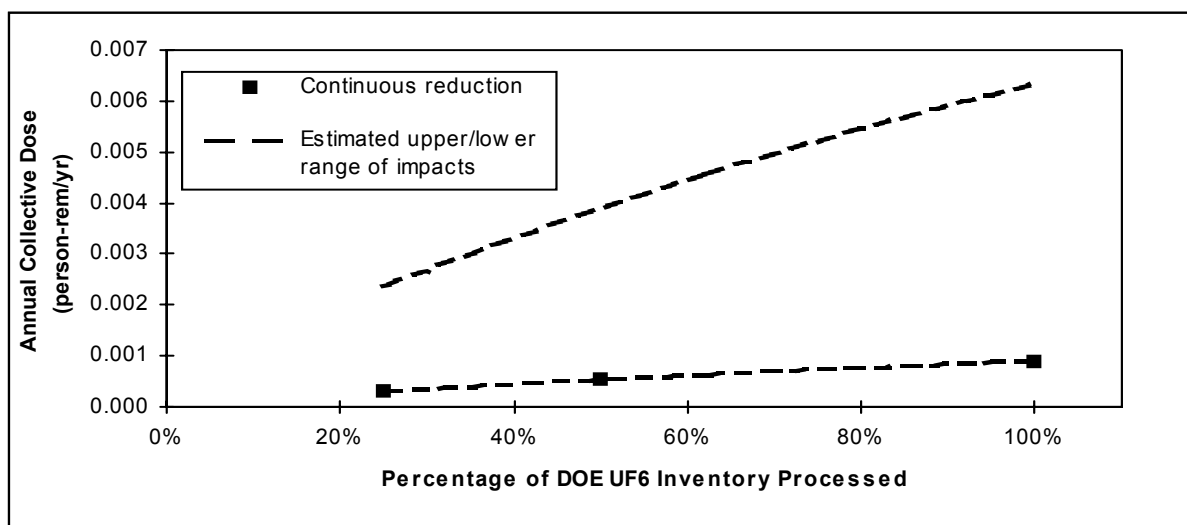


FIGURE 8.15 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF₆ to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

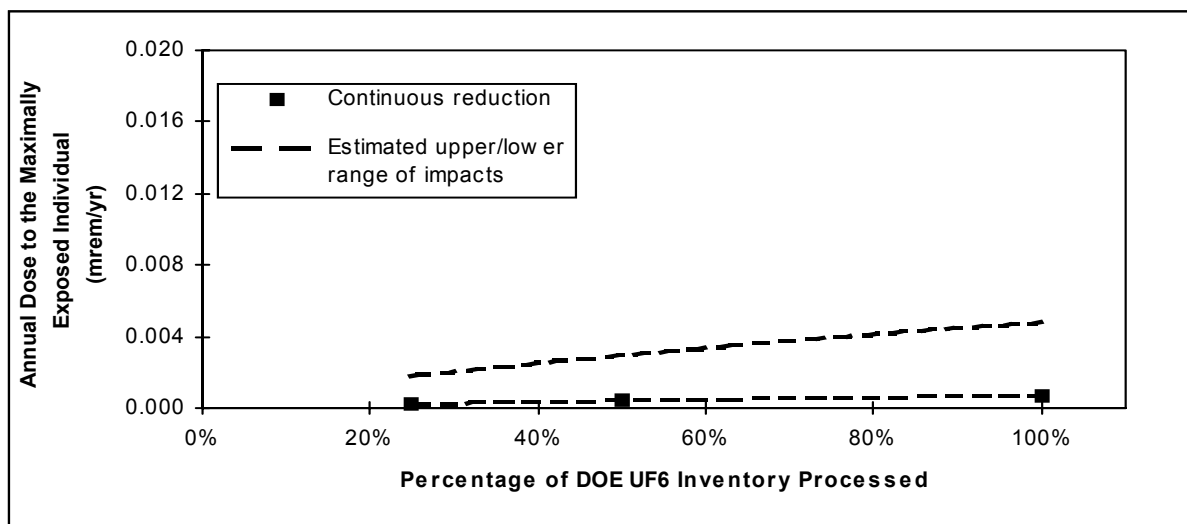


FIGURE 8.16 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF₆ to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

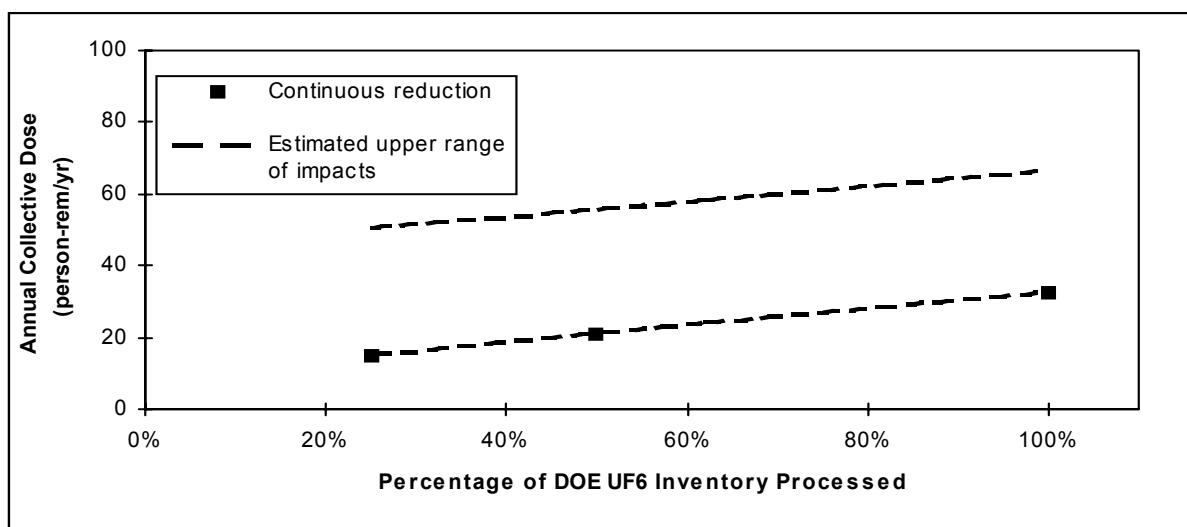


FIGURE 8.17 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF₆ to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

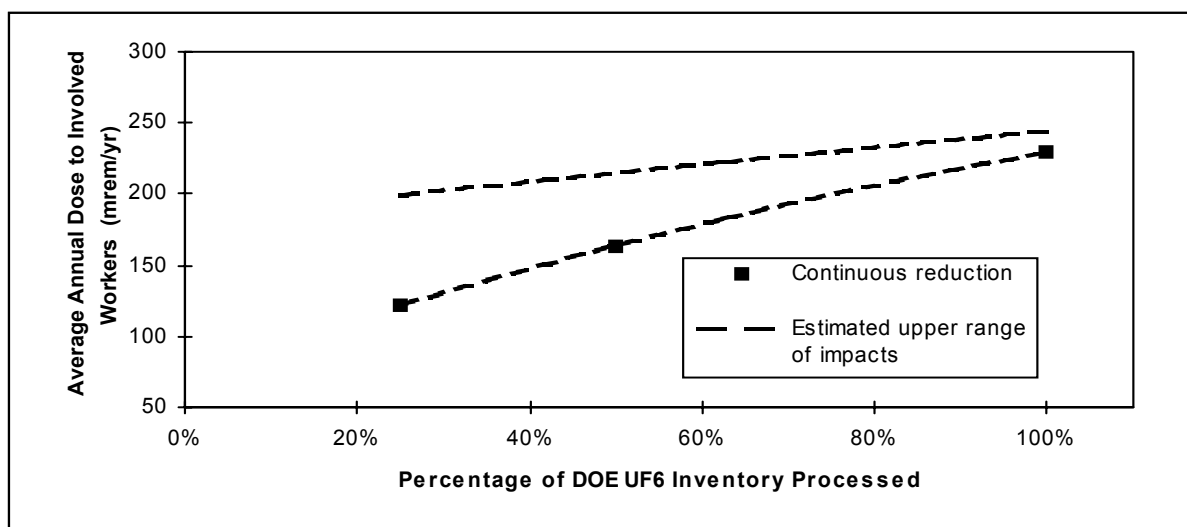


FIGURE 8.18 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF₆ to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

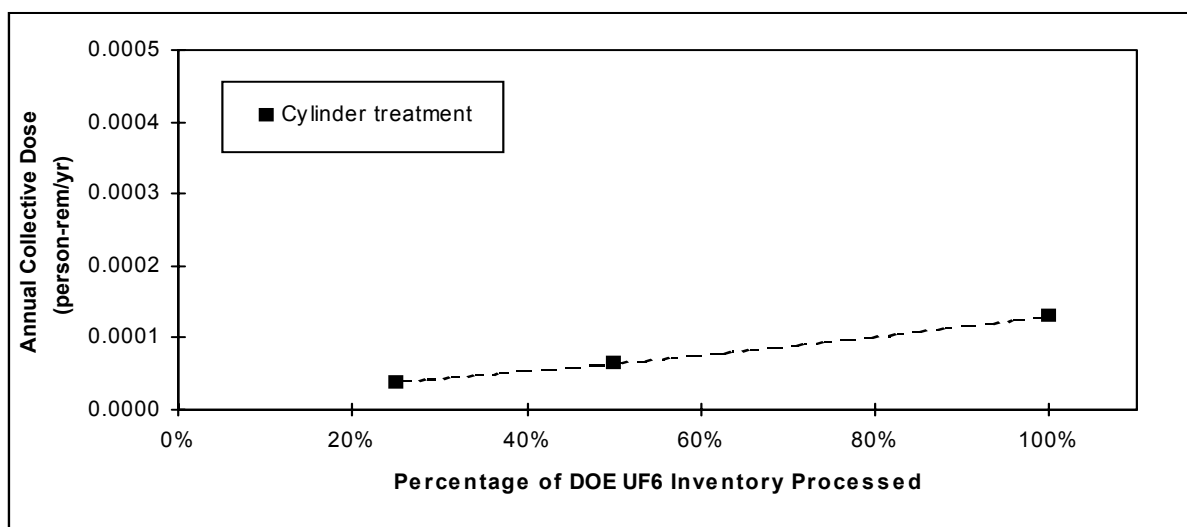


FIGURE 8.19 Estimated Annual Collective Dose to Members of the Public from the Cylinder Treatment Facility

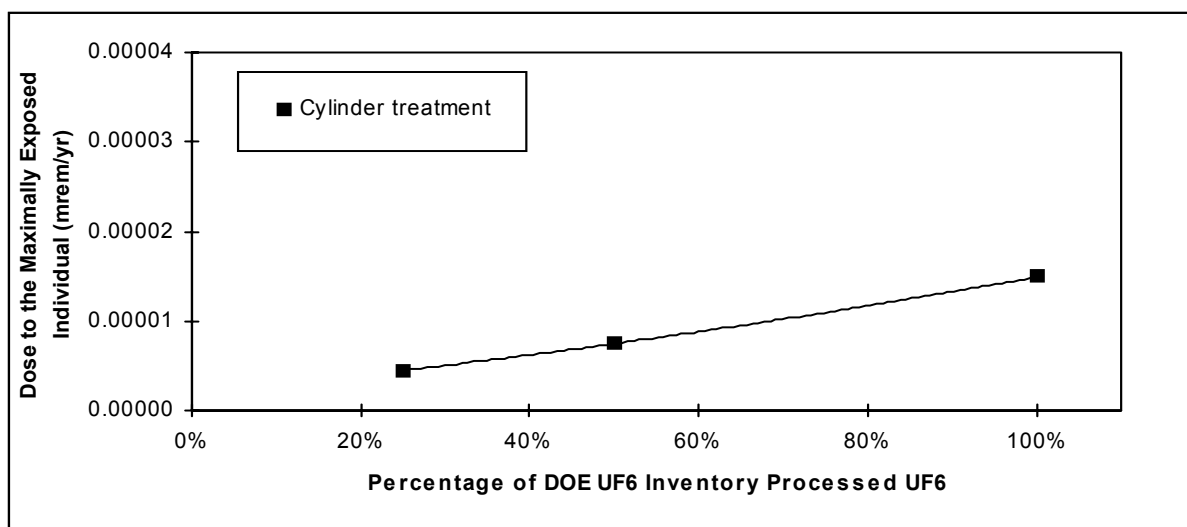


FIGURE 8.20 Estimated Annual Dose to the General Public MEI from the Cylinder Treatment Facility

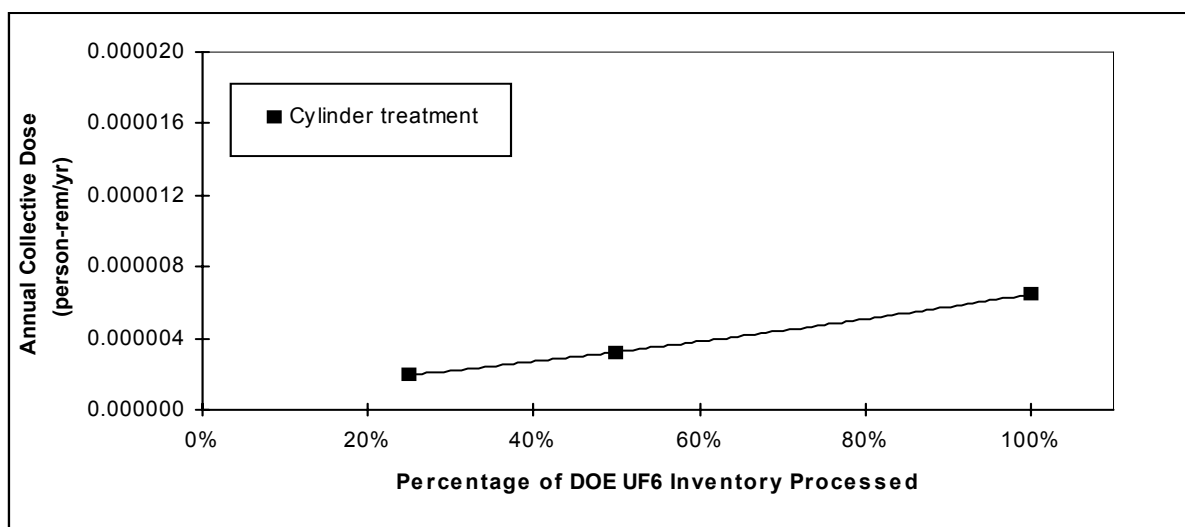


FIGURE 8.21 Estimated Annual Collective Dose to Noninvolved Workers from the Cylinder Treatment Facility

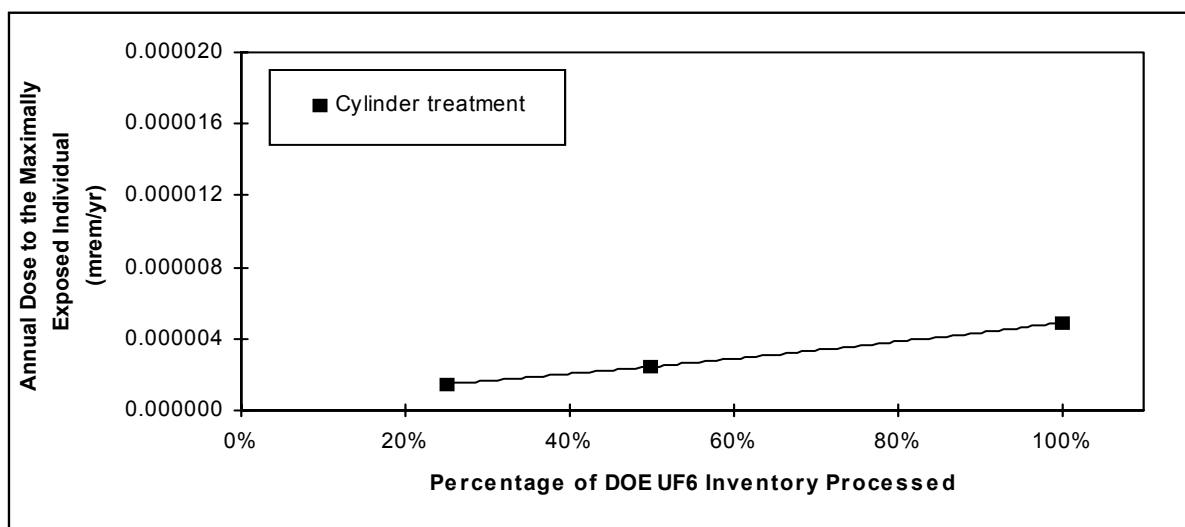


FIGURE 8.22 Estimated Annual Dose to the Noninvolved Worker MEI from the Cylinder Treatment Facility

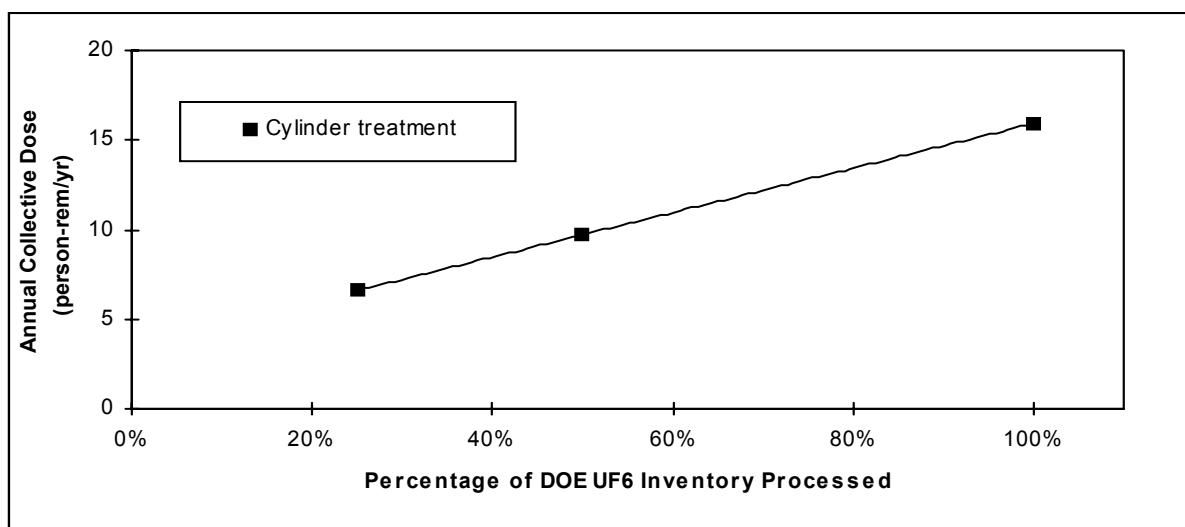


FIGURE 8.23 Estimated Annual Collective Dose to Involved Workers from the Cylinder Treatment Facility

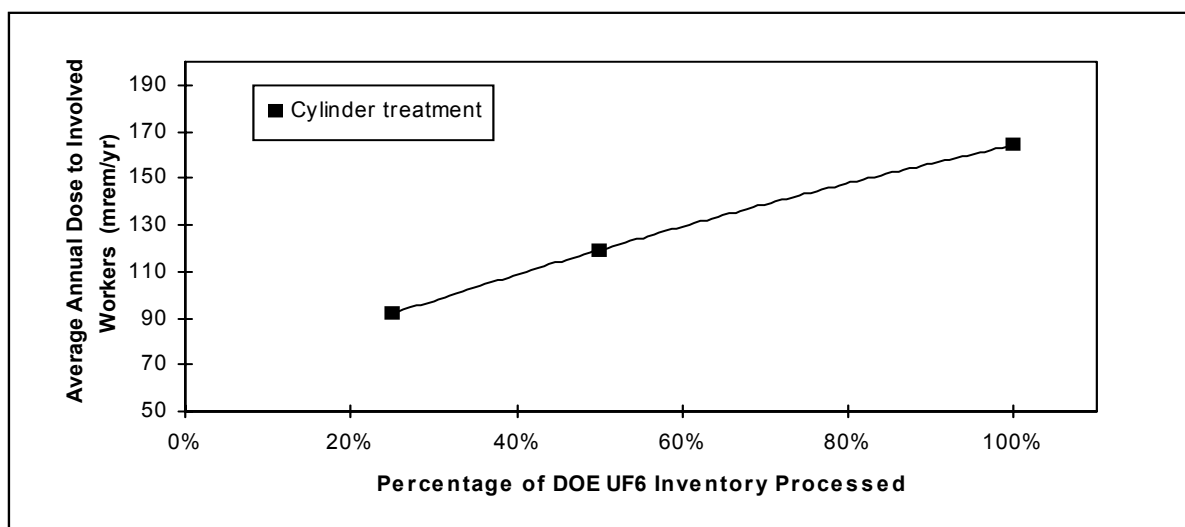


FIGURE 8.24 Estimated Annual Average Individual Dose to Involved Workers from the Cylinder Treatment Facility

8.2.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) facilities for converting depleted UF_6 to U_3O_8 , UO_2 , and uranium metal are described in Section 5.3.1.2. Results of the 100% case analyses indicated that noninvolved workers and members of the general public would receive very low exposures to chemicals from operation of the conversion facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 for all three conversion options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, calculated hazard indices for noninvolved workers and members of the general public were proportionally smaller than those for the 100% cases. Therefore, because the hazard indices are much less than 1, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100%.

The chemical impacts from operations of the cylinder treatment facility were estimated to be less than the impacts from operations of the conversion facilities, therefore resulting in no adverse health impacts to noninvolved workers and the general public for the 25%, 50%, and 100% cases.

8.2.2 Human Health — Accident Conditions

8.2.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during operation of the full-scale (100%) conversion facilities are presented in Section 5.3.2.1. Analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997) for the 25% and 50% throughput cases.

On the basis of the assessment of the 25% and 50% conversion cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% cases in Section 5. The impacts would be the same because the bounding accidents within each frequency category (those producing the greatest consequences) would be the same for all cases (100%, 50%, and 25%). The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding) would be different than those for the 100% cases. In general, the impacts of these nonbounding accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

All accidents associated with the cylinder treatment facilities discussed in Section 5 would be the same for the parametric analysis (LLNL 1997). The frequencies of some accidents, such as drum spills, might decrease as the number of drums handled decreased with facility throughput. However, it is not expected that the small changes in frequencies for specific accidents would change the overall frequency category for those accidents. As a result, the accident impacts associated with the cylinder treatment facility would be the same for all parametric cases.

8.2.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) conversion facilities are presented in Section 5.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997) for the 25% and 50% throughput cases.

As for the radiological accident impacts, the chemical accidents producing the greatest consequences for the 25% and 50% parametric cases would be the same as those assessed for the 100% cases in Section 5. The impacts would be similar because the bounding accidents within most frequency categories would be the same for the 100%, 50%, and 25% cases, and in those cases where the accidents were different, no adverse chemical impacts were estimated. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding accidents) would be different than those for the 100% cases. In general, the impacts of these other accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

All accidents associated with the cylinder treatment facilities discussed in Section 5 would be the same for the parametric analysis (LLNL 1997). The frequencies of some accidents, such as drum spills, might decrease as the number of drums handled decreased with facility throughput. However, it is not expected that the small changes in frequencies for specific accidents would change the overall frequency category for those accidents. As a result, the overall chemical accident impacts associated with cylinder treatment would be the same for all parametric cases.

8.2.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) conversion facilities are presented in Section 5.3.2.3. The impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case).

The estimated total fatalities over the entire period of construction and operations for the U_3O_8 conversion options for the 25%, 50%, and 100% cases would be 0.29, 0.32, and 0.35, respectively (both conversion options analyzed resulted in the same fatality estimates). For the UO_2 conversion options, the estimated total fatalities for the 25%, 50%, and 100% cases would range from 0.35 to 0.49, 0.38 to 0.54, and 0.40 to 0.59, respectively. For the metal conversion options, total fatalities for the 25%, 50%, and 100% cases would range from 0.33 to 0.49, 0.36 to 0.52, and 0.4 to 0.55, respectively.

The total numbers of injuries over the entire period of construction and operation of the specific U_3O_8 , UO_2 , and metal conversion options analyzed parametrically are illustrated by the solid black line in Figures 8.25 through 8.27. The estimated upper ranges of impacts for all options examined in the PEIS are illustrated by the dotted lines in the figures (because both U_3O_8 options analyzed resulted in the same number of estimated injuries, only one line is shown in Figure 8.25). The ranges of predicted injury incidence for the conversion options would be roughly comparable, reflecting the generally similar requirements for constructing and operating the three types of conversion facilities.

The estimated fatalities for the 25%, 50%, and 100% cases of construction and operation of a cylinder treatment facility would be 0.13, 0.16, and 0.19, respectively. The estimated number of injuries over the entire period of construction and operations would range from 122 to 170. The impacts are shown in Figure 8.28 for throughputs ranging from 25% to 100%.

8.2.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) conversion facilities are presented in detail in Section 5.3.3. All of the pollutant concentrations produced by the 100% capacity version of the conversion facilities would be well below their respective air quality standards, with the possible exception of dust emissions during construction. During construction, short-term particulate concentrations were estimated to potentially approach the applicable air quality standards for all options, although the condition would be temporary and minimized by good construction practices. The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases, and impacts during operations would also be negligible. However, the air quality impacts from operations would not scale proportionally with facility capacities. The impacts from a 25% capacity plant would be from about 45% to 100% of those from the full-capacity plant, depending on the specific source of the emissions.

All of the pollutant concentrations produced by the 100% capacity version of the cylinder treatment facility would be well below the respective air quality standards (see Section 5.3.3). The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided

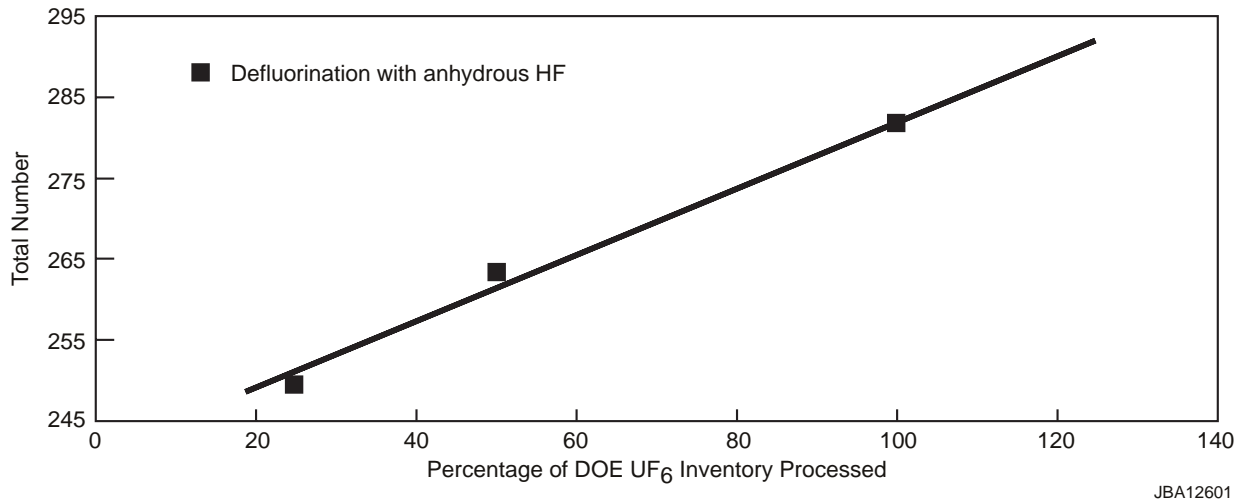


FIGURE 8.25 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF_6 to U_3O_8 (No range is presented because the number of injuries would be almost identical between the U_3O_8 conversion technologies.)

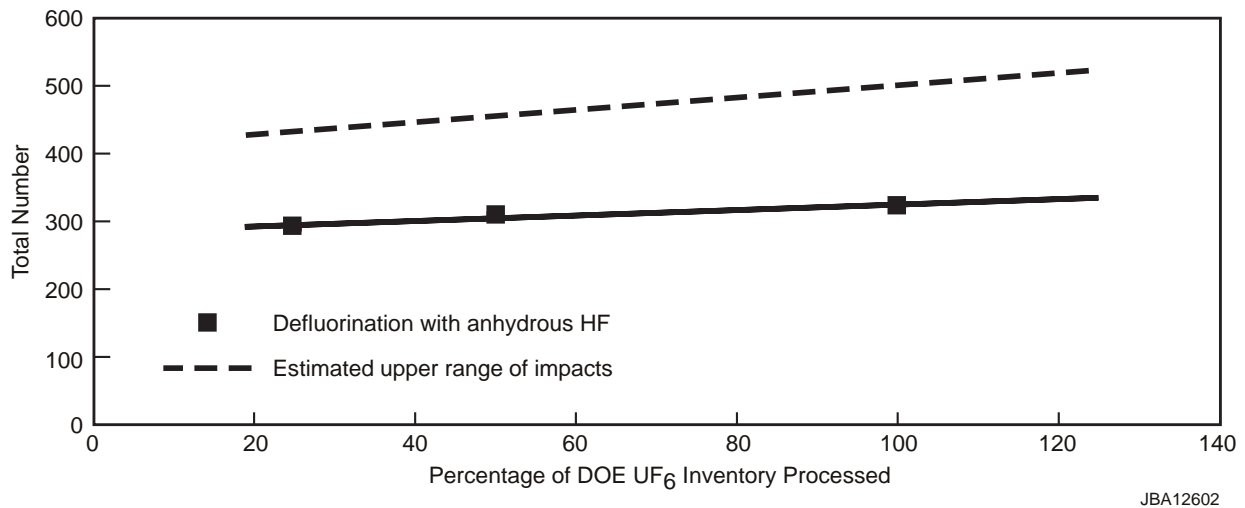


FIGURE 8.26 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF_6 to UO_2 (The ranges reflect differences in UO_2 conversion technologies.)

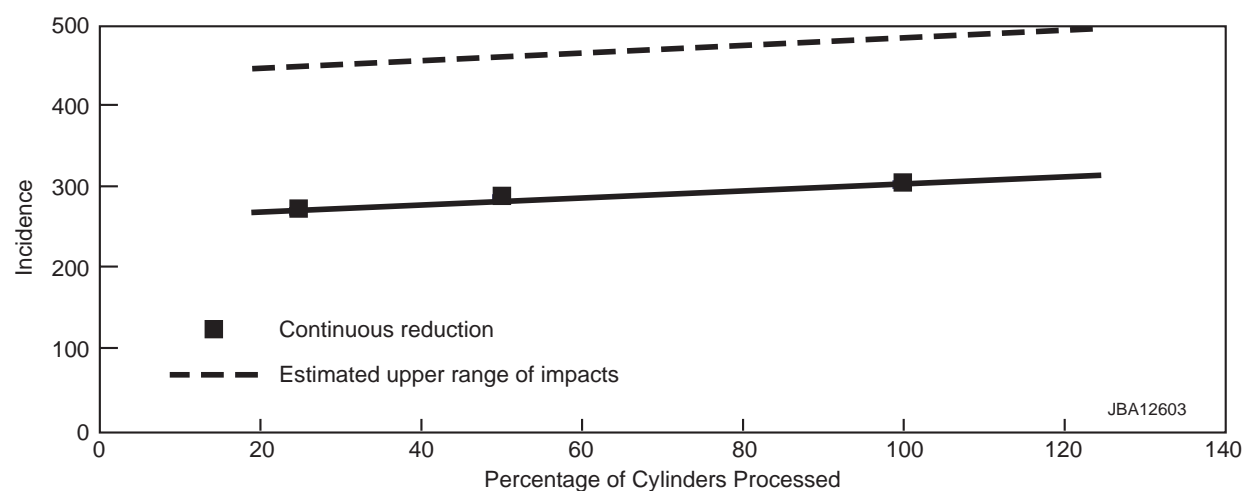


FIGURE 8.27 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF_6 to Uranium Metal (The ranges reflect differences in uranium metal conversion technologies.)

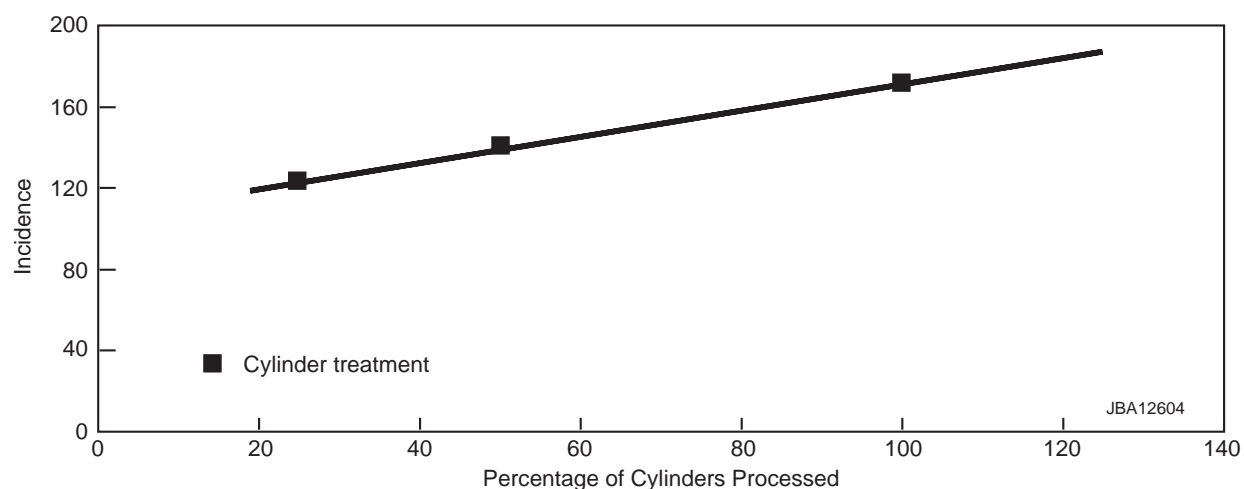


FIGURE 8.28 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Cylinder Treatment Facility

in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases, and thus would also be negligible.

8.2.4 Water and Soil

8.2.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Section 5.3.4.1. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for all three conversion options. The impacts to surface water estimated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases, and thus would also be negligible.

8.2.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Section 5.3.4.2. The potential impacts evaluated included changes in the depth to groundwater, the direction of groundwater flow, recharge, and quality. The impacts to groundwater from the 100% cases were found to be negligible for all three conversion options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases, and thus would also be negligible.

8.2.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Section 5.3.4.3. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to be negligible for all three conversion options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases, and thus would also be negligible.

8.2.5 Socioeconomics

The socioeconomic impacts of U_3O_8 , UO_2 , and metal conversion and cylinder treatment facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor between cases would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller conversion and cylinder treatment facilities would result in the following: less direct and indirect employment and income would be created in the ROI; fewer people would migrate into the ROI with fewer total jobs created, meaning fewer rental and owner-occupied houses would be needed; and the impact on local jurisdictional revenues and expenditures would be smaller.

8.2.6 Ecology

Site preparation for the construction of conversion and cylinder treatment facilities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures, paved areas, and landscaping (see Section 8.2.9). Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

Normal operations of the conversion facility would generate minor atmospheric emissions of criteria pollutants, HF, and uranium compounds. However, resulting air concentrations would be expected to be negligible under all conversion options analyzed, resulting in negligible impacts to ecological resources.

Effluent discharges to surface water would contain low levels of contaminants, including uranium. However, under all three conversion cases, contaminant concentrations in the undiluted effluent would be below levels that adversely affect aquatic biota.

Depending on the exact location of the conversion facility, the loss of approximately 10 to 30 acres (4 to 12 ha) of undeveloped land and habitat, representing the rounded 25-100% capacity range for oxide and metal conversion facilities, might constitute a minor to moderate adverse impact to vegetation and wildlife. For the cylinder treatment facility, the loss of 6.8 to 8.7 acres (2.8 to 3.5 ha) of undeveloped land and the permanent loss of 3.2 to 4.5 acres (1.3 to 1.8 ha) of habitat would constitute a negligible to low adverse impact. (See Section 8.2.9 for details on land use assumptions.) When these facilities would be sited, all appropriate measures would be taken to preclude or minimize such impacts.

Impacts to wetlands and state and federally protected species due to facility construction would depend on the location of the facility within the site. Avoidance of wetland areas would be

included during facility planning. Impacts to air quality, surface water, groundwater, and soil during construction and operations would be expected to be negligible, as would the resulting derived impacts to ecological resources.

8.2.7 Waste Management

The estimated impacts from waste management operations for construction and operation of full-scale (100%) conversion facilities are presented in detail in Section 5.3.7. Potential moderate impacts to site, regional, and national waste management operations were found for all 100% throughput conversion option cases. On the basis of information provided in the engineering analysis report (LLNL 1997), the impacts resulting from construction and operation of the conversion facility for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal waste management impacts would result from construction-generated wastes. The annual amounts of waste generated during facility operations are shown in Table 8.2. Overall, the waste input resulting from normal operations at the conversion facilities would have a low to moderate impact on waste management capacities locally or across the DOE complex.

There is a significant possibility that the MgF_2 waste generated in the conversion to metal option would be sufficiently contaminated with uranium to require disposal as LLW rather than as solid nonhazardous waste. Such disposal might require the MgF_2 waste to be grouted, generating up to 12,300 m^3/yr of grouted waste for LLW disposal. This volume represents a low (5.8%) impact to the DOE complexwide LLW disposal capacity for the 100% throughput case (scales linearly for the three throughput cases).

8.2.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) conversion facilities are presented in detail in Section 5.3.8. The impacts on resources would be expected to be small for the 100% capacity conversion case. Although the resource requirements for the two conversion parametric analyses would be less than the 100% case, the reduction in requirements would not be linearly proportional to the decrease in throughput. For example, the amount of material required to construct a conversion facility for the 25% throughput case would be only about 10% to 20% less than the amount required for the 100% throughput facility due to “economies-of-scale.”

Construction and operation of the proposed conversion options would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be consumed during construction or operation. The conversion options are not considered resource-intensive, and the resources required are generally not considered rare or unique. Furthermore,

TABLE 8.2 Waste Generation from Conversion Facilities for 100%, 50%, and 25% Throughput Cases

Waste Category	Waste Generated (m ³ /yr) by Conversion to U ₃ O ₈ , UO ₂ , or Uranium Metal for Three Throughput Cases								
	U ₃ O ₈			UO ₂			Uranium Metal		
	100%	50%	25%	100%	50%	25%	100%	50%	25%
Low-level radioactive waste									
Combustible	77	73	70	88	84	82	77	71	69
Noncombustible	62	45	33	82	63	45	112	88	69
Grouted	466	233	116	466	233	116	37	26	18
Low-level mixed waste	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Hazardous waste	7.3	6.7	6.1	7.3	6.7	6.1	7.3	6.7	6.1
Nonhazardous waste									
Solids	535	512	490	612	585	566	6,680 ^a	3,590 ^a	2,040 ^a
Wastewater	58,000	36,300	24,600	74,900	47,300	31,000	96,500	57,500	37,500
Sanitary waste	4,920	4,730	4,540	5,680	5,380	5,220	5,300	4,950	4,800

^a Includes the following volumes of MgF₂ waste: 6,120 m³/yr for the 100% case; 3,060 m³/yr for the 50% case, and 1,530 m³/yr for the 25% case.

committing any of these resources would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

Construction and operation of a cylinder treatment facility would also consume irretrievable amounts of electricity, fuel, concrete, steel, water, and miscellaneous gases and chemicals. Similar to the conversion facilities, the cylinder treatment facility option would not be expected to result in negative impacts relative to its resource requirements.

8.2.9 Land Use

8.2.9.1 Conversion to U_3O_8

Potential impacts to land use from the construction and operation of a U_3O_8 conversion facility would include the acquisition and clearing of required land, minor and temporary disruptions to contiguous land parcels, and increases in vehicular traffic. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to U_3O_8 by defluorination with anhydrous HF would require the disturbance of approximately 14, 16, and 20 acres (5.5, 6.4, and 8.1 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 9, 11, and 13 acres (3.6, 4.2, and 5.3 ha) with structures, paved areas, and landscaping. The amount of land required for the other U_3O_8 conversion technologies would be roughly similar. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts, particularly if the facility was sited in a location already dedicated to similar use with immediate access to infrastructure and utility support.

Impacts to land use outside the boundaries of a U_3O_8 conversion facility at 25%, 50%, or 100% of throughput would be limited to negligible, temporary traffic impacts associated with project construction.

8.2.9.2 Conversion to UO_2

Impacts to land use from the construction and operation of a UO_2 conversion facility, regardless of throughput capacity case, would be negligible and limited to minor and temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to UO_2 by the dry process with anhydrous HF would require the disturbance of approximately 16, 19, and 24 acres (6.4, 7.9, and 9.7 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 10, 13, and 15 acres (4.0, 5.2, and 5.9 ha) with structures, paved areas, and landscaping. The amount of land required for the other UO_2 conversion technologies would be roughly similar, except for gelation, which would require a

slightly greater amount of land. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts associated with construction.

Impacts to land use outside the boundaries of a UO_2 conversion facility at 25%, 50%, or 100% of throughput would be limited to minor, temporary traffic impacts associated with project construction.

8.2.9.3 Conversion to Uranium Metal

Impacts to land use from the construction and operation of a facility for uranium metal conversion, regardless of throughput capacity case, would be negligible and limited to minor and temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to uranium metal by the continuous metallothermic production technology would require the disturbance of approximately 17, 21, and 26 acres (6.8, 8.6, and 10.6 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 12, 14, and 15 acres (4.8, 5.5, and 6.2 ha) with structures, paved areas, and landscaping. The amount of land required for the other uranium metal conversion technology would be roughly similar. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts associated with construction.

Impacts to land use outside the boundaries of a conversion-to-metal facility at 25%, 50%, or 100% of throughput would be limited to minor, temporary traffic impacts associated with project construction.

8.2.9.4 Cylinder Treatment Facility

Other than negligible and temporary disruptions to contiguous land parcels, and slight increases in vehicular traffic, virtually no impacts would be expected from a cylinder treatment facility at 25%, 50%, or 100% of throughput capacity. Site preparation for construction of a stand-alone cylinder treatment facility for 25%, 50%, and 100% of the depleted UF_6 inventory would require the disturbance of approximately 6.8, 7.5, and 8.7 acres (2.8, 3.0, and 3.5 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 3.2, 3.7, and 4.5 acres (1.3, 1.5, and 1.8 ha) with structures and paved areas.

Potential impacts to land use outside the boundaries of a site containing a cylinder treatment facility at 25%, 50%, or 100% of throughput capacity would be limited to negligible, temporary traffic impacts associated with project construction.

8.2.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the conversion options considered in the PEIS were implemented — including impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of conversion facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without considering specific locations for construction at the Paducah site, which are not currently known. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific locations are considered.
- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the ROD for the PEIS.

8.3 LONG-TERM STORAGE OPTIONS

The parametric analysis of the long-term storage options considered the environmental impacts of storing 25% and 50% of the depleted UF_6 inventory as UF_6 or as an oxide form. In both cases, it was assumed that the uranium material would be actively placed into storage over a 20-year period (from 2009 through 2028), and then stored for an additional 11-year period (from 2029 through 2039) with only routine monitoring and maintenance. The assessment considered the environmental impacts that would occur during (1) construction of a storage facility, (2) routine operations, and (3) potential storage facility accidents. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases discussed in detail in Section 6. The supporting engineering data for the 25% and 50% parametric storage cases are provided in the engineering analysis report (LLNL 1997).

The environmental impacts for the 100% case are presented in Section 6 for (1) storage as UF_6 in yards and buildings, (2) storage as U_3O_8 in buildings and vaults, and (3) storage as UO_2 in buildings and vaults. For the purposes of the parametric analysis, storage as UF_6 in buildings and storage as UO_2 in buildings were considered in detail. These options were chosen to simplify the parametric analysis because all options were evaluated in detail for the 100% base case. The relationships between the options that were identified for the 100% case were used to infer the impacts for all of the long-term storage options for the parametric analysis.

8.3.1 Human Health — Normal Operations

8.3.1.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from the normal operation of full-scale (100%) storage facilities for depleted UF_6 cylinders, UO_2 drums, and U_3O_8 drums are described in Section 6.3.1.1. Similar impacts were calculated for the 50% and 25% storage facilities for the parametric analysis. Radiological impacts from the storage as UF_6 , UO_2 , and U_3O_8 would be limited to involved workers because emissions of uranium to the air and water would be expected to be negligible during normal operations. The radiological impacts for involved workers for the 100%, 50%, and 25% cases are shown in Figures 8.29 through 8.34. The range of impacts resulting from technology differences (i.e., differences between yard, building, and vault storage facilities) are represented by dashed lines in the figures. The results for the two parametric cases for storage in buildings are shown in the figures as solid points, with a curve drawn between the points to indicate how the impacts would vary as a function of the percent of depleted UF_6 processed. The upper and lower bounds of impacts for the 25% and 50% cases were estimated on the basis of the range determined for the different technologies for the 100% case. The area enclosed by the lines in the figures indicates the range of impacts expected for throughputs between 25% and 100%.

The results of the parametric analysis (as shown in Figures 8.29 and 8.34) indicate that the collective radiological impacts would scale relatively linearly with the total quantity of depleted UF_6 processed. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Section 6.3.1.1.

Detailed numerical results for each of the parametric analyses can be found in the tables and attached disks of Cheng et al. (1997). For radiation exposure of the involved workers, the results are presented in Table 6.1 of Cheng et al. (1997) and on disk 4 under the file name store-tm.xls.

8.3.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) storage facilities are described in Section 6.3.1.2. The results of the 100% case analyses indicated that noninvolved workers and members of the general public would receive very low exposures to chemicals from operation of all storage facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 for all

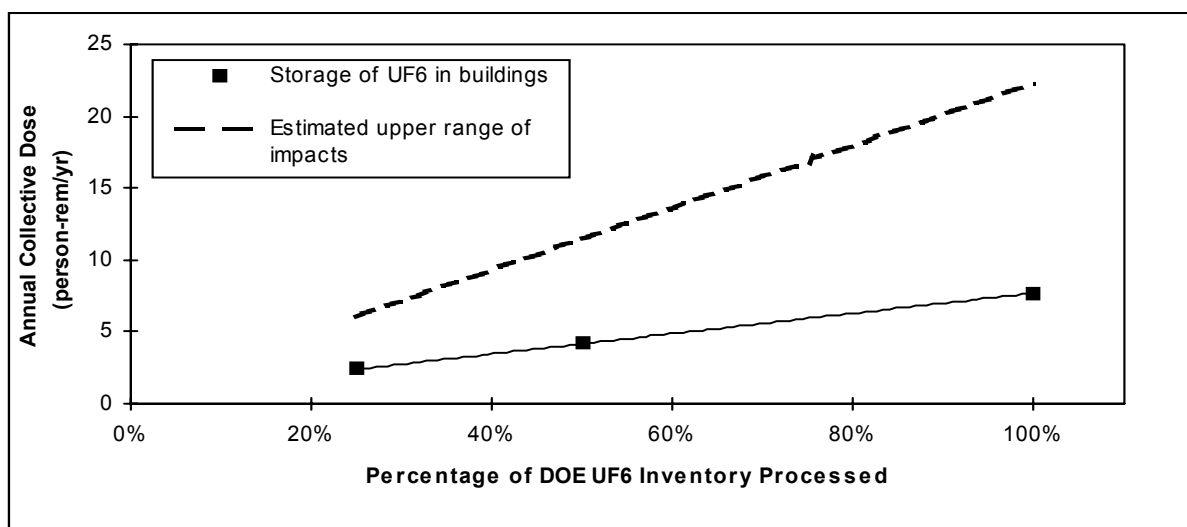


FIGURE 8.29 Estimated Annual Collective Dose to Involved Workers from Storage as UF₆ (The upper and lower ranges reflect differences in storage technologies, i.e., buildings and yards.)

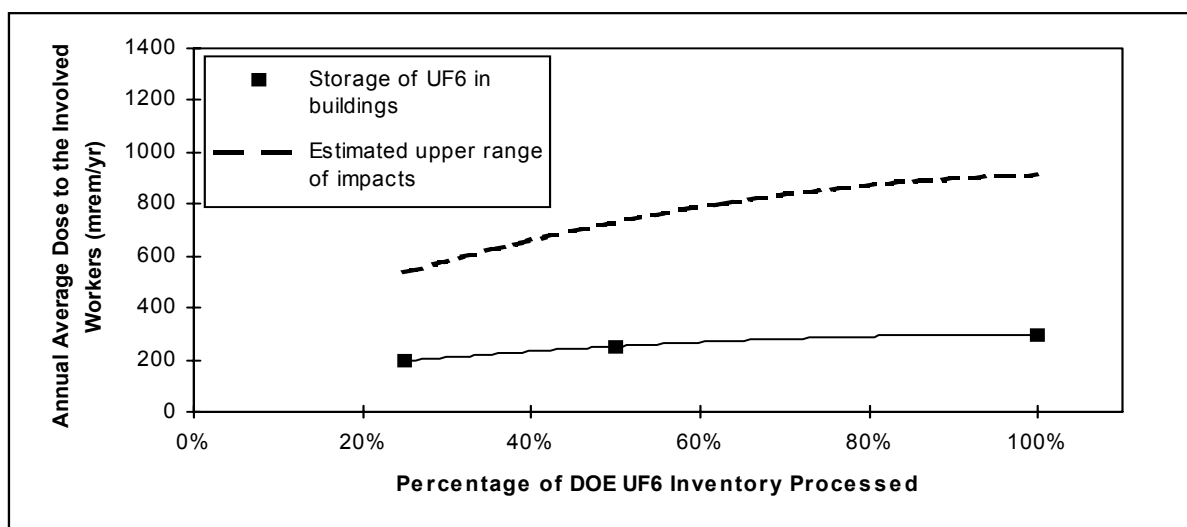


FIGURE 8.30 Estimated Annual Average Individual Dose to Involved Workers from Storage as UF₆ (The upper and lower ranges reflect differences in storage technologies, i.e., buildings and yards.)

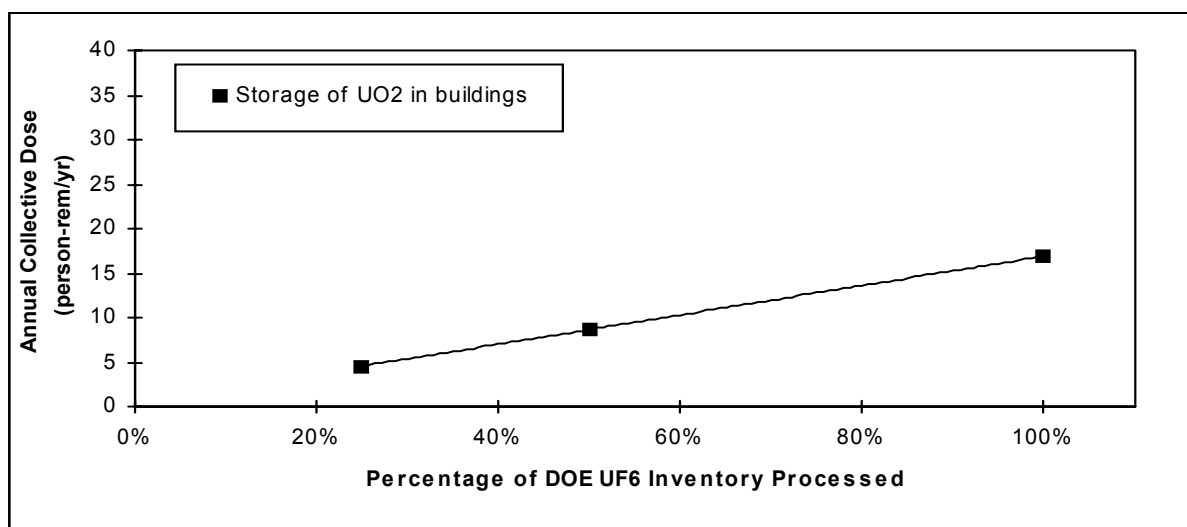


FIGURE 8.31 Estimated Annual Collective Dose to Involved Workers from Storage as UO₂ (The collective doses for the different storage technologies would be essentially the same.)

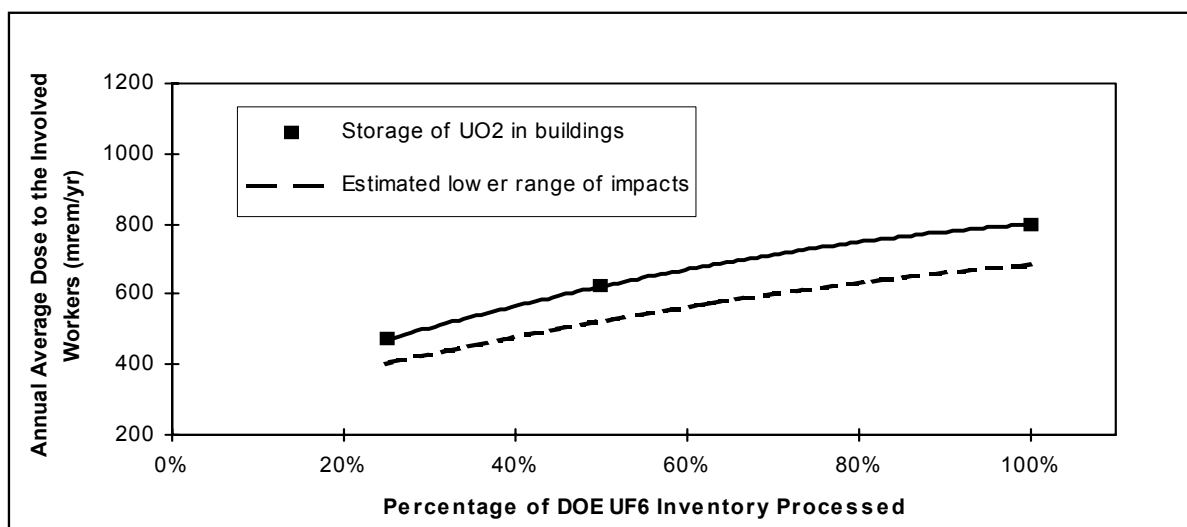


FIGURE 8.32 Estimated Annual Average Individual Dose to Involved Workers from Storage as UO₂ (The upper and lower ranges reflect differences in storage technologies, i.e., buildings and vaults.)

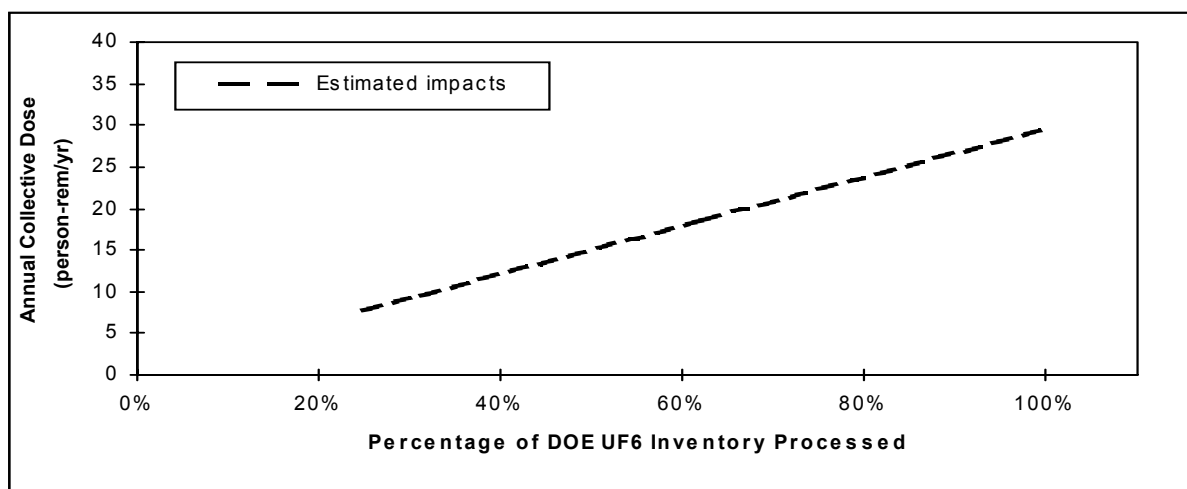


FIGURE 8.33 Estimated Annual Collective Dose to Involved Workers from Storage as U_3O_8 (Collective doses for different options are about the same.)

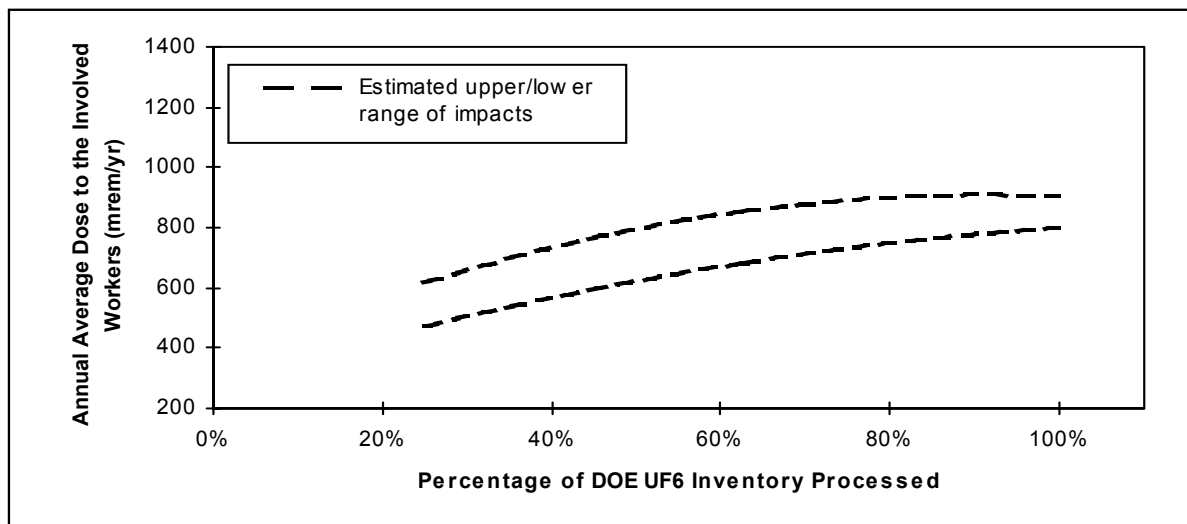


FIGURE 8.34 Estimated Annual Average Individual Dose to Involved Workers from Storage as U_3O_8 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings and vaults.)

long-term storage options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, airborne emissions of depleted uranium and HF during normal operations would be less than the 100% cases and extremely small (LLNL 1997). Therefore, by comparison with the 100% case results, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100% for all long-term storage options.

8.3.2 Human Health — Accident Conditions

8.3.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during the operation of full-scale (100%) storage facilities for depleted UF_6 , U_3O_8 , and UO_2 are presented in Section 6.3.2.1. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% long-term storage cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% case in Section 6.3.2.1. The impacts would be identical because the bounding accidents within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents that were related to handling operations (i.e., the “mishandle/drop of drum” accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the long-term storage options would be the same for all parametric cases.

8.3.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) storage facilities for UF_6 and oxide are presented in Section 6.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% long-term storage cases, the chemical accident impacts associated with each of the parametric cases would be the same as those presented for the 100% case in Section 6.3.2.2. As for radiological accidents, the impacts would be the same because the bounding accidents within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents related to handling operations (i.e., the “mishandle/drop of drum” accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the long-term storage options would be the same for all parametric cases.

8.3.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) storage facilities are presented in Section 6.3.2.3. For the 100% storage cases, worker fatalities ranged from about 0.10 to 0.25 for storage as UF_6 , 0.14 to 0.16 for storage as UO_2 , and 0.26 to 0.29 for storage as U_3O_8 (see Table 6.11). On-the-job worker injuries for the 100% cases ranged from about 90 to 150 for storage as UF_6 , from 150 to 165 for storage as U_3O_8 , and from 100 to 110 for storage as UO_2 . For the two options analyzed in detail in the parametric analysis, the impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than 50% of the impacts for the 100% case).

For parametric cases, the number of on-the-job worker fatalities for storage as UF_6 would range from 0.05 to 0.08 at 25% capacity and from about 0.07 to 0.14 at 50% capacity. For storage as UO_2 , fatalities would range from 0.07 to 0.10 at 25% capacity and would be about 0.10 at 50% capacity. The number of on-the-job worker injuries for storage as UF_6 would range from about 50 to 64 at 25% capacity and from about 60 to 93 at 50% capacity. For storage as UO_2 , injuries would range from about 50 to 70 at 25% capacity and would be about 75 at 50% capacity. The predicted number of injuries for UF_6 and UO_2 are shown as a function of throughput in Figures 8.35 and 8.36, respectively.

Although parametric cases for the U_3O_8 storage options were not explicitly analyzed, if it is assumed that the relative difference in magnitude of impacts for U_3O_8 and UO_2 is similar to that for the 100% cases, then the number of on-the-job fatalities for storage as U_3O_8 would range from about 0.13 to 0.18 for 25% capacity and from about 0.19 to 0.21 at 50% capacity. Estimated injuries for parametric cases of storage as U_3O_8 would range from about 75 to 105 for 25% capacity and from about 113 to 125 for 50% capacity.

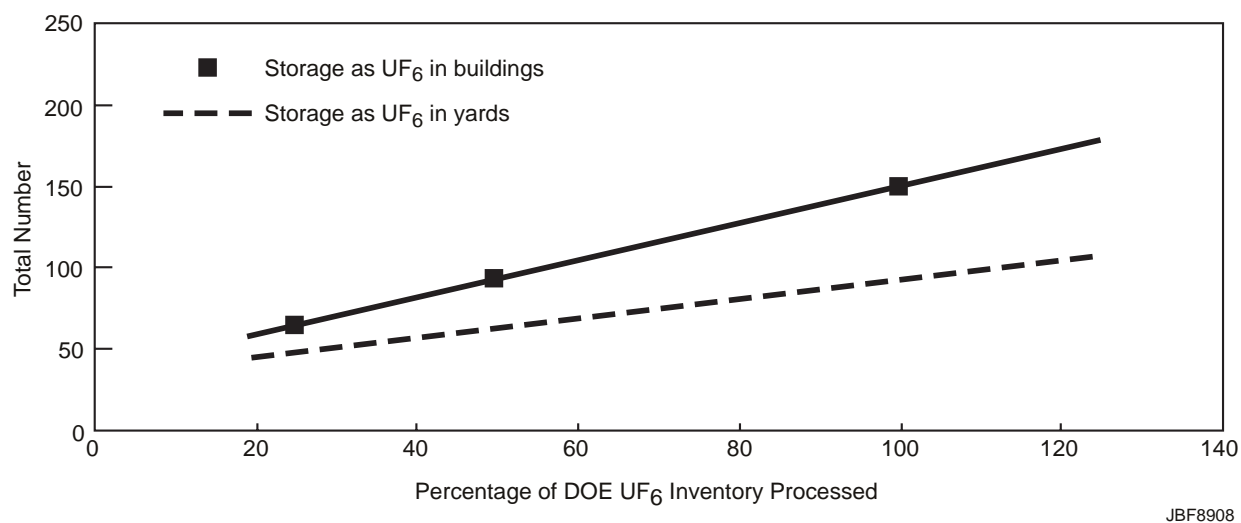


FIGURE 8.35 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for Storage as UF₆ (The range reflects differences in storage technologies, i.e., buildings and yards.)

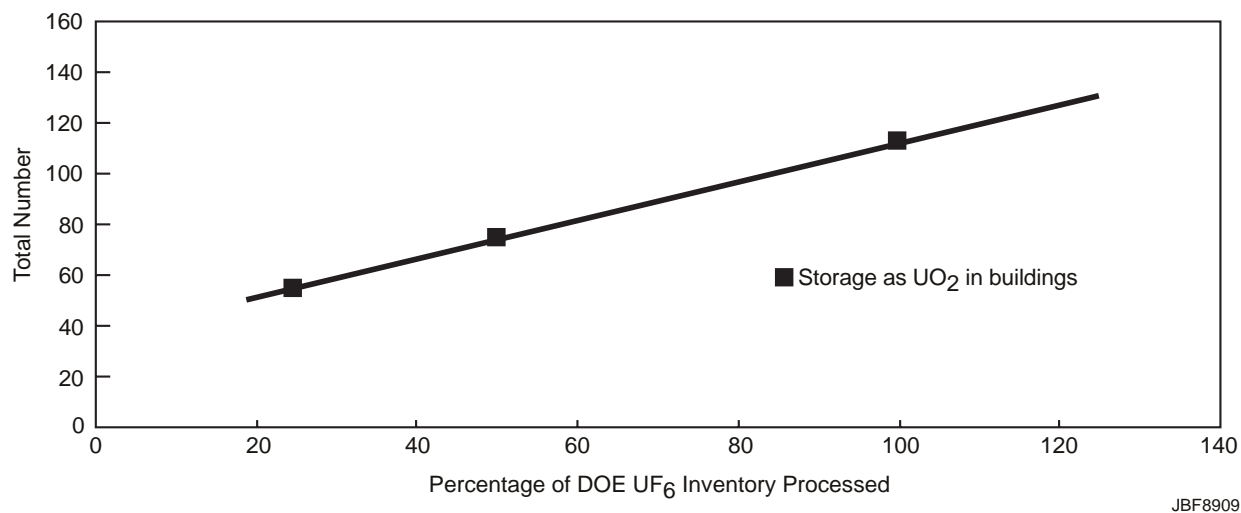


FIGURE 8.36 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for Storage as UO₂ (No range is presented because the estimates for storage in buildings and vaults are almost identical.)

8.3.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Section 6.3.3. All of the pollutant concentrations resulting from 100% throughput would be below the respective air quality standards. During construction, short-term particulate concentrations would potentially approach the applicable air quality standards for all options, although the condition would be temporary and minimized by good construction practices. During operations, the pollutant concentrations would be less than 0.1% of the corresponding air quality standards, resulting in negligible impacts.

The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases; impacts during operations would also be negligible. The air quality impacts from storage were found to scale roughly proportionally with throughput. The impacts from the 50% case for both construction and operations would be about 0.6 of those from the 100% case for both UF_6 and UO_2 ; the impacts for construction for the 25% case would be 0.25 and 0.32 times the 100% case for UF_6 and UO_2 , respectively; and the impacts for operations for the 25% case would be only about 0.2 times the 100% case for both UF_6 and UO_2 .

8.3.4 Water and Soil

8.3.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) storage facilities for UF_6 and oxide are presented in detail in Section 6.3.4.1. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for all storage options for both UF_6 and oxide (including storage of U_3O_8). The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases, and thus would also be negligible.

8.3.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) storage facilities for UF_6 and oxide are presented in detail in Section 6.3.4.2. The potential impacts evaluated included changes in depth to groundwater, direction of groundwater flow, recharge, and groundwater quality. The impacts to groundwater from the 100% cases were found to be negligible for all storage options for both UF_6 and oxide (including storage

of U_3O_8). The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997), were found to be less than those for the 100% cases, and thus would also be negligible.

8.3.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Section 6.3.4.3. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to have potentially moderate, but temporary, impacts for all storage options. These moderate impacts would result from material excavated during construction that would be left on-site. In the long term, contouring and reseeded would return soil conditions back to their former state, and the impacts would be negligible. The impacts calculated for the 25% and 50% parametric cases for storage of UF_6 and UO_2 in buildings, based on information provided in the engineering analysis report (LLNL 1997), were also found to have moderate, but temporary, impacts on soil, similar to the 100% cases. In the long term, impacts on soil would be negligible for all storage options.

8.3.5 Socioeconomics

The socioeconomic impacts of UF_6 and UO_2 long-term storage facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller UF_6 and UO_2 long-term storage facilities would result in the following: less direct and indirect employment and income in the ROI would be created at the site; fewer people would migrate into the ROI with fewer total jobs created, meaning fewer rental and owner-occupied houses would be needed; and the impact on local jurisdictional revenues and expenditures would be smaller.

8.3.6 Ecology

Impacts to ecological resources could occur during construction of UF_6 storage facilities for all options, although impacts during operations would be negligible. Impacts due to construction and operation of a facility to store UO_2 in buildings would be similar to impacts from storage of UF_6 . Site preparation activities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures and paved areas (see Section 8.3.9). Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

Depending on the exact location of the UF₆ facility, the loss of 40 to 130 acres (16 to 53 ha) of undeveloped land and habitat might constitute a moderate to large adverse impact to vegetation and wildlife. (See Section 8.3.9 for details on land use assumptions.) Depending on the exact location of the UO₂ facility, the loss of 40 to 80 acres (16 to 32 ha) of undeveloped land and habitat might constitute a moderate adverse impact. However, when these facilities were sited, all appropriate measures would be taken to preclude or minimize such impacts.

Impacts to wetlands and state and federally protected species due to facility construction would depend on the location of the storage facility within the Paducah site. Avoidance of wetland areas and site-specific surveys for protected species would be included during facility planning.

8.3.7 Waste Management

The estimated impacts from waste management operations from the construction and operation of full-scale (100%) long-term storage facilities for UF₆ and oxide are presented in detail in Section 6.3.7. On the basis of information provided in the engineering analysis report (LLNL 1997), the impacts resulting from construction and operation of the long-term storage facility for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal to moderate, but temporary, waste management impacts would result from construction wastes. Negligible impacts would be associated with all waste forms generated during operations. Overall, the waste input resulting from storage facilities would have negligible impact on waste management capacities locally or across the DOE complex.

8.3.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) long-term storage facilities for UF₆ and oxide are presented in detail in Section 6.3.8. The impacts on resources would be expected to be small for the 100% capacity storage case for all options. Resource requirements for the two parametric cases considered would be less than those for the 100% case (LLNL 1997). In general, the amounts of construction materials would be roughly proportional to the storage capacity because the majority of the construction materials would be for the actual storage buildings and the number of storage buildings required would be linearly related to the required storage capacity.

Construction and operation of the proposed storage facilities would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be consumed during construction or operation for all long-term storage options. The storage options are not considered resource-intensive, and the resources required are generally not considered rare or unique. Furthermore, committing any of these resources would not be expected to cause a negative

impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

8.3.9 Land Use

Impacts to land use from the construction and operation of UF_6 storage buildings would be limited to the clearing of required land, potential minor and temporary disruptions to contiguous land parcels, and a slight increase in vehicular traffic. Site preparation for construction of a facility to store 25%, 50%, and 100% of the depleted UF_6 inventory in buildings would require the disturbance of approximately 42, 72, and 131 acres (17, 29, and 53 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 16, 30, and 62 acres (6.5, 12, and 25 ha) with structures and paved areas. The amount of land required for the other UF_6 storage options would be generally similar.

Land for storage buildings would be cleared incrementally over the projected 20-year construction project, thereby reducing the potential for land disturbance and consequential land disruption impacts. Such potential impacts, however, would be greatest at 100% of throughput capacity. Also, the areal requirement of 131 acres (53 ha) for the 100% capacity case could result in land-use changes if an existing site with limited open space were chosen.

Road and rail access within a storage site would be designed to minimize on-site traffic conflicts. For off-site traffic, only temporary, minor impacts associated with construction vehicles would be expected.

Storage as UO_2 would be expected to generate only negligible impacts to land use and would result in a lower areal requirement and less land disturbance compared with storage as UF_6 . Site preparation for the construction of a facility to store 25%, 50%, and 100% of the depleted UF_6 inventory as UO_2 in buildings would require the disturbance of approximately 37, 49, and 79 acres (15, 20, and 32 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 13, 20, and 35 acres (5.1, 8.1, and 14 ha) with structures and paved areas. The amount of land required for the other uranium oxide storage options would be generally similar.

Land for storage buildings would be cleared incrementally over the projected 20-year construction project, thereby reducing the potential for land disturbance and consequential land disruption impacts. Such potential impacts, however, would be greatest at 100% of throughput capacity. The peak labor force during the 20-year construction period, regardless of throughput capacity, would not be large enough to generate other than negligible off-site traffic impacts.

8.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the long-term storage options considered in this PEIS were implemented — including impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of storage facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without considering specific locations for construction at the Paducah site, which are not currently known. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific locations are considered.
- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the ROD for the PEIS.

9 REFERENCES

Allison, T., 1996, "Baseline Unemployment Statistics," memorandum from T. Allison to H. Avci (Argonne National Laboratory, Argonne, Ill.), Oct. 23.

Allison, T., and S. Folga, 1997, *Socioeconomic Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from T. Allison and S. Folga (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

ANL: see Argonne National Laboratory.

Argonne National Laboratory, 1991, *Environmental Site Description for a Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) Production Plant at the Paducah Gaseous Diffusion Plant Site*, ANL/EAIS/TM-59, prepared by Argonne National Laboratory, Argonne, Ill., for U.S. Department of Energy, Office of Nuclear Energy, Sept.

BEA: see U.S. Bureau of Economic Analysis.

Cash, J.M., 1996, facsimile transmittal, with attachments, from J.M. Cash (Three-Site UF₆ Cylinder Management Program, Lockheed Martin Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tenn.) to H.M. Hartmann (Argonne National Laboratory, Argonne, Ill.), Oct. 4.

Cash, J.M., 1997, "Paducah Cylinder Yard Drawing," attachment to facsimile transmittal from J.M. Cash (Transportation Technologies Group, Oak Ridge National Laboratory, Oak Ridge, Tenn.) to H.M. Hartmann (Argonne National Laboratory, Argonne, Ill.), June 20.

CDM Federal Programs Corporation, 1994, *Investigation of Sensitive Ecological Resources inside the Paducah Gaseous Diffusion Plant*, Document Control Number 7916-003-FR-BBRY, prepared by CDM, Paducah, Ky., for U.S. Department of Energy, Paducah Gaseous Diffusion Plant, and Martin Marietta Energy Systems, Inc., Paducah, Ky., Aug. 19.

Charles, L.D., et al., 1991, *Cost Study for the D&D of the GDPs: Depleted Uranium Management and Conversion*, K/D-5940-F, Martin Marietta Energy Systems, Oak Ridge, Tenn.

Cheng, J.-J., et al., 1997, *Human Health Impact Analyses for Normal Operations in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from J.-J. Cheng (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

DOE: see U.S. Department of Energy.

DOE and USEC: see U.S. Department of Energy and United States Enrichment Corporation.

EPA: see U.S. Environmental Protection Agency.

ERC/EDGE, 1989, *The Geologic Setting of the DOE Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, Knoxville, Tenn., Oct. 17.

Folga, S., 1996a, "Information Requested Concerning the Transfer Facility," cc:mail transmittal from S. Folga (Argonne National Laboratory, Argonne, Ill.) to D. Tomasko et al. (Argonne National Laboratory, Argonne, Ill.), Nov. 7.

Folga, S., 1996b, "Scaling Approach for the Cylinder Treatment and Overpack," cc:mail transmittal from S. Folga (Argonne National Laboratory, Argonne Ill.) to H. Avci et al. (Argonne National Laboratory, Argonne, Ill.), May 9.

Folga, S., 1996c, "Total Workforce for the Overpack Concept in the DUF6 PEIS," cc:mail transmittal from S. Folga (Argonne National Laboratory, Argonne, Ill.) to H. Hartmann et al. (Argonne National Laboratory, Argonne, Ill.), Nov. 5.

Hodges, J., 1996, "Average Exposure Data for Cylinder Yard Workers," attachment to facsimile transmittal from J. Hodges (Paducah Gaseous Diffusion Plant, Paducah, Ky.) to C.E. Bradley (U.S. Department of Energy, Washington, D.C.), Jan. 23.

Hogan, D., 1996, "Emissions Inventory System: Plant Actual Emissions in Tons per Year," facsimile transmittal from D. Hogan (Kentucky Division of Air Quality, Frankfort, Ky.) to M. Monarch (Argonne National Laboratory, Argonne, Ill.), Dec. 5.

Lawrence Livermore National Laboratory, 1997, *Depleted Uranium Hexafluoride Management Program; the Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride*, UCRL-AR-124080, Volumes I and II, prepared by Lawrence Livermore National Laboratory, Science Applications International Corporation, Bechtel, and Lockheed Martin Energy Systems for U.S. Department of Energy.

LMES: see Lockheed Martin Energy Systems, Inc.

Lockheed Martin Energy Systems, Inc., 1996, *Paducah Site Annual Environmental Report for 1994*, ES/ESH-60 (KY/EM-79), prepared by Environmental, Safety, and Health Compliance and Environmental Management staffs, Oak Ridge, Tenn., and Environmental Management Division, Paducah Site, Paducah, Ky., for U.S. Department of Energy, Feb.

Lockheed Martin Energy Systems, Inc., 1997a, *1995 Annual Environmental Report*, KY/EM-176, prepared by Environmental Management Division, Kevil, Ky., for U.S. Department of Energy, Jan.

Lockheed Martin Energy Systems, Inc., 1997b, *Safety Analysis Report, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, Revision R0-A, KY/EM-174, Paducah, Ky.

Lockheed Martin Energy Systems, Inc., 1997c, *Paducah Site Annual Environmental Report for 1996*, KY/EM-206, prepared by Environmental Management Division, Kevil, Ky., for U.S. Department of Energy, Dec.

Lockheed Martin Energy Systems, Inc., 1997d, *UF₆ Cylinder Project Management Plan*, K/TSO-30, Rev. 2, prepared by Project Support Organization, East Tennessee Technology Park, Oak Ridge, Tenn., for U.S. Department of Energy, July.

Lockheed Martin Energy Systems, Inc., 1997e, *K-25 Site UF₆ Cylinder Storage Yards Final Safety Analysis Report*, K/D-SAR-29, prepared for the U.S. Department of Energy, Feb. 28.

Lockheed Martin Energy Systems, Inc., 1997f, *Safety Analysis Report, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, POEF-LMES-89, Rev. RO-A, prepared for U.S. Department of Energy, Jan.

Lyon, B.F., 1996, "Materials Required for PEIS," memorandum from B.F. Lyon (Oak Ridge National Laboratory, Oak Ridge, Tenn.) to J.M. Cash (Lockheed Marietta Energy Research Corporation, Oak Ridge, Tenn.), Nov. 20.

Lyon, B.F., 1997, e-mail transmittal from B.F. Lyon (Oak Ridge National Laboratory, Oak Ridge, Tenn.) to H. Hartmann (Argonne National Laboratory, Argonne, Ill.), March 4 (with correction, March 19).

Martin Marietta Energy Systems, Inc., 1990, *U-AVLIS Site Data Package, Paducah Gaseous Diffusion Plant*, KY/A-553, Paducah, Ky., Oct.

Martin Marietta Energy Systems, Inc., 1994a, *Paducah Gaseous Diffusion Plant, Annual Site Environmental Report for 1993*, ES/ESH-53 (KY/ERWM-18), prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., and Paducah, Ky., for U.S. Department of Energy, and by Martin Marietta Utility Services, Inc., for United States Enrichment Corporation, Oct.

Martin Marietta Energy Systems, Inc., 1994b, *Paducah Gaseous Diffusion Plant, Annual Site Data for 1993*, ES/ESH-55 (KY/ERWM-20), prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., and Paducah, Ky., for U.S. Department of Energy, and by Martin Marietta Utility Services, Inc., for United States Enrichment Corporation, Oct.

McGuire, S.A., 1985, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*, NUREG-1140, Draft Report for Comment, U.S. Nuclear Regulatory Commission, Washington, D.C., June.

MMES: see Martin Marietta Energy Systems, Inc.

National Council on Radiation Protection and Measurements, 1987, *Ionizing Radiation Exposures of the Population of the United States*, NCRP Report No. 93, Bethesda, Md.

National Safety Council, 1995, *Accident Facts*, 1995 ed., Itasca, Ill.

Nieves, L.A., et al., 1997, *Analysis of Options for Disposition of Empty Depleted UF₆ Cylinders*, attachment to memorandum from L.A. Nieves et al. (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

NRC: see U.S. Nuclear Regulatory Commission.

Parks, J.W., 1997, "Data for Revised No Action Alternative in the Depleted UF₆ Programmatic Environmental Impact Statement," memorandum from J.W. Parks (Assistant Manager for Enrichment Facilities, EF-20, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tenn.) to C.E. Bradley (U.S. Department of Energy, Office of Facilities, NE-40, Germantown, Md.), April 7.

Pawel, S.J., 1997, "Technical Basis for Cylinder Painting Schedule" (letter report ORNL/CST-SP-021097-06), attachment to memorandum from S.J. Pawel (Oak Ridge National Laboratory, Oak Ridge, Tenn.) to M.S. Taylor et al. (Oak Ridge National Laboratory, Oak Ridge, Tenn.), Feb. 10.

Policastro, A.J., et al., 1997, *Facility Accident Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from A.J. Policastro (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), June 15.

Rogers, J.G., et al., 1988, *Environmental Surveillance of the U.S. Department of Energy Paducah Reservation and Surrounding Environs during 1987*, ES/ESH-4/V3, prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., for U.S. Department of Energy, April.

Sadri, R.J., 1995, letter from R.J. Sadri (Project Manager, Regulatory Branch, U.S. Army Corps of Engineers, Louisville District, Ky.) to J. Hodges (Site Manager, Department of Energy, Oak Ridge Operations, Paducah Site Office, Paducah, Ky.), Dec. 14.

Standard & Poor's, 1996, *Industry Surveys, Metals: Industrial*, McGraw-Hill Book Co., New York, N.Y., Nov. 21, p. 1.

Tomasko, D., 1997a, *Threshold Surface Water Runoff Calculations for the No Action Alternative in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from D. Tomasko (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

Tomasko, D., 1997b, *Water and Soil Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from D. Tomasko (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

Tschanz, J., 1997a, *Air Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from J. Tschanz (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

Tschanz, J., 1997b, *Bounding Case HF Concentrations for the No Action Alternative*, memorandum from J. Tschanz (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), April 16.

U.S. Bureau of Economic Analysis, 1996, *Illinois and Kentucky County Projections to 2040*, U.S. Department of Commerce, Regional Economic Analysis Division, Washington, D.C.

U.S. Bureau of the Census, 1992a, *Tiger Line Files*, U.S. Department of Commerce, Washington, D.C.

U.S. Bureau of the Census, 1992b, *1990 Census of Population and Housing*, Summary File Tape 1 on CD-ROM (machine-readable data files), U.S. Department of Commerce, Washington, D.C.

U.S. Bureau of the Census, 1992c, *1990 Census of Population and Housing*, Summary File Tape 3 on CD-ROM (machine-readable data files), U.S. Department of Commerce, Washington, D.C.

U.S. Bureau of the Census, 1994, *County and City Data Book, 1994*, 12th ed., Economics and Statistics Administration, Washington, D.C., Aug., pp. 149–150, 219–220, 233–234, 429–430, 443–444, 499–500, 513–514.

U.S. Bureau of the Census, 1996, *Statistical Abstract of the United States: 1996*, 116th ed., Washington, D.C., p. 750.

U.S. Department of the Army, 1994a, *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky; Volume IV, Cultural Resources Investigation; Part A, Results of Field Investigation*, Final Report, Volume 4A, prepared by Waterways Experiment Station, Corps of Engineers Environmental Laboratory, Vicksburg, Miss., and Engineer District Nashville, Nashville, Tenn., for U.S. Department of Energy, Oak Ridge Operations, Paducah Site Office, Paducah, Ky., May.

U.S. Department of the Army, 1994b, *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky; Volume IV, Cultural Resources Investigation; Part B, Sensitivity Analysis*, Final Report, Volume 4B, prepared by Waterways Experiment Station, Corps of Engineers Environmental Laboratory, Vicksburg, Miss., and Engineer District Nashville, Nashville, Tenn., for U.S. Department of Energy, Oak Ridge Operations, Paducah Site Office, Paducah, Ky., May.

U.S. Department of the Army, 1994c, *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky; Volume II, Wetlands, Investigation*, Final Report, Volume 2, prepared by Waterways Experiment Station, Corps of Engineers Environmental Laboratory, Vicksburg, Miss., and Engineer District Nashville, Nashville, Tenn., for U.S. Department of Energy, Oak Ridge Operations, Paducah Site Office, Paducah, Ky., May.

U.S. Department of Commerce, 1997, *Statistical Abstract of the United States*, 117th edition, Economic and Statistics Administration, Oct.

U.S. Department of Commerce, 1999, *U.S. Census Bureau, Annual Survey of Manufactures, Geographic Area Statistics*, <http://www.census.gov/prod/www/abs/geograph.html>.

U.S. Department of Energy, 1992, *Radiological Control Manual*, DOE/EH-0256T, Assistant Secretary for Environment, Safety and Health, Washington, D.C., June.

U.S. Department of Energy, 1994, *Remedial Investigation Addendum for Waste Area Grouping 23, PCB Sites at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1149 & D2 (KY/ER-32 & D2), Revision 2, Sept.

U.S. Department of Energy, 1995a, *Depleted Uranium: A DOE Management Challenge*, DOE/EM-0262, Office of Environmental Management, Office of Technology Development, Washington, D.C., Oct.

U.S. Department of Energy, 1995b, *Integrated Data Base Report — 1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 11, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., for U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C., Sept.

U.S. Department of Energy, 1995c, *Mixed Waste Inventory Summary Report*, DOE/M96-GT-029, Washington, D.C.

U.S. Department of Energy, 1996, *Technical Report on Affected Environment for the DOE Sites Considered in the DOE Waste Management Programmatic Environmental Impact Statement (WMPEIS)*, Volumes I and II, META/Berger-SR-01, prepared by META/Berger, Gaithersburg, Md., for U.S. Department of Energy, Office of Environmental Management, Dec.

U.S. Department of Energy, 1997, *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, DOE/EIS-0200-F, Office of Environmental Management, Washington, D.C., May.

U.S. Department of Energy, 1998, *Draft Environmental Assessment of Proposed Treatment of Mixed Wastes at the Paducah Gaseous Diffusion Plant Using the Vortec Vittrification System*, DOE/EA-1230, Oak Ridge Operations Office, Oak Ridge, Tenn.

U.S. Department of Energy, 1999a, *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, DOE/EIS-0269, Office of Nuclear Energy, Science and Technology, Apr.

U.S. Department of Energy, 1999b, *Record of Decision for Long-Term Management and Use of Depleted Uranium Hexafluoride*, Office of Nuclear Energy, Science and Technology, July.

U.S. Department of Energy and United States Enrichment Corporation, 1998a, *Memorandum of Agreement Relating to Depleted Uranium Generated Prior to the Privatization Date*, May 18.

U.S. Department of Energy and United States Enrichment Corporation, 1998b, *Memorandum of Agreement Relating to Depleted Uranium*, June 30.

U.S. Environmental Protection Agency, 1995, *Risk-Based Concentration Table, July-December 1995*, Region III, Hazardous Waste Management Division, Office of Superfund Programs, Philadelphia, Penn., Oct.

U.S. Environmental Protection Agency, 1996, *Drinking Water Regulations and Health Advisories*, EPA 882-B-96-002, Office of Water, Washington, D.C., Oct., pp. 1–11.

U.S. Nuclear Regulatory Commission, 1994, "10 CFR Part 19, et al., Certification of Gaseous Diffusion Plants; Final Rule," discussion on Section 76.85, "Assessment of Accidents," *Federal Register* 59(184):48954-48955, Sept. 23.

U.S. Nuclear Regulatory Commission, 1995, *Environmental Assessment for Renewal of Source Material License, SUB-526, Docket 40-3392, AlliedSignal, Inc., Metropolis, Illinois*, Division of Fuel Cycle Safety and Safeguards, Washington, D.C.